THE TECH ENGINEERING NEWS

Volume XXV OCTOBER 1943 Number 1

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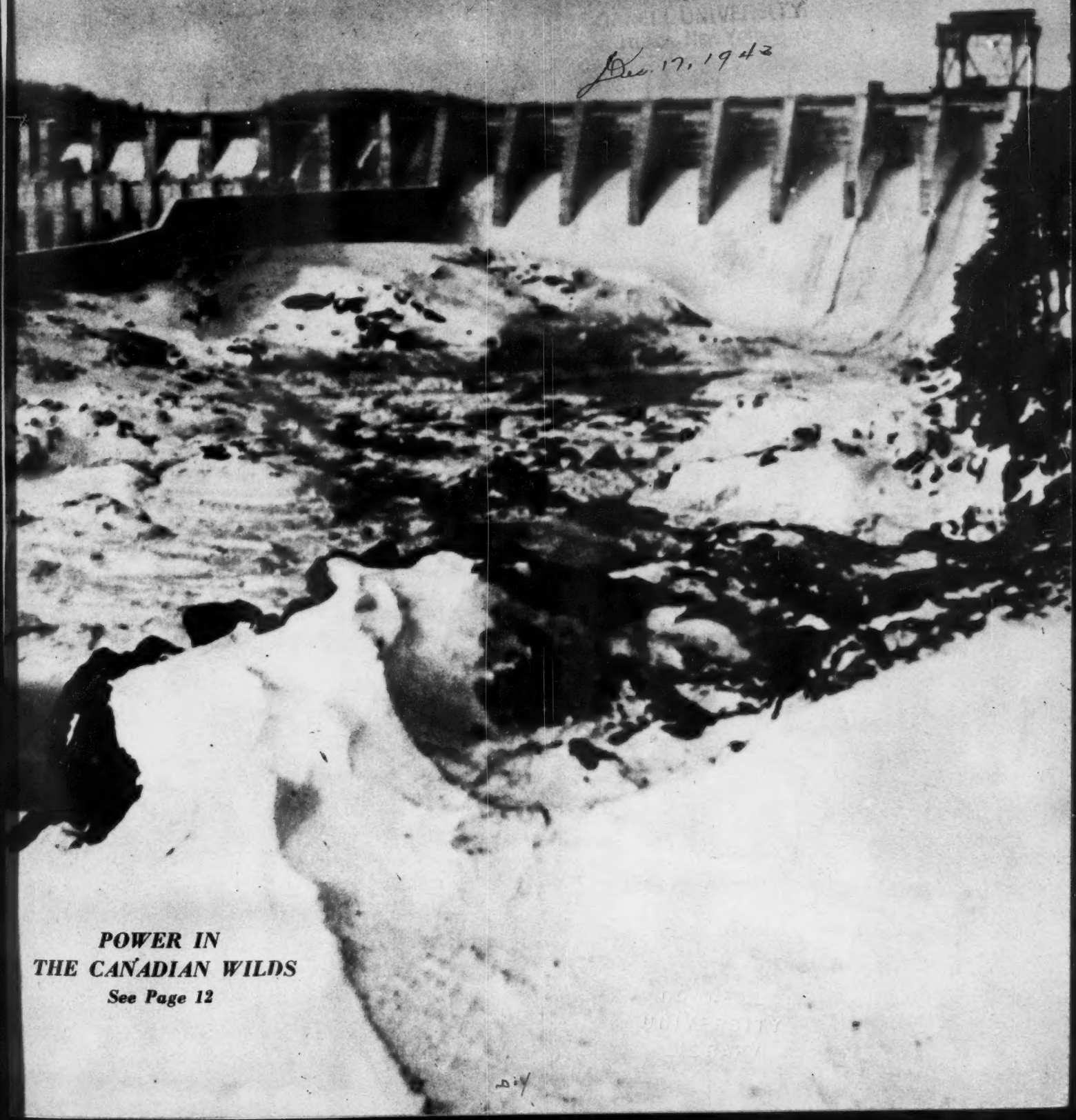

POWER IN THE CANADIAN WILDS

See Page 12

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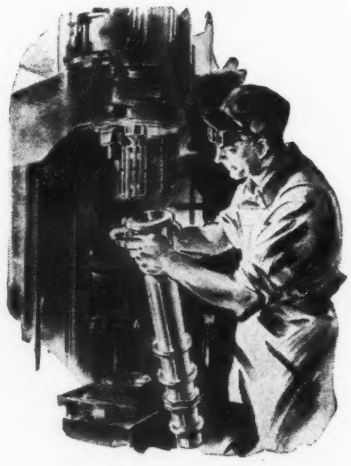
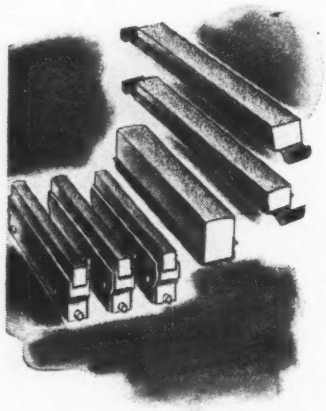
Landing at 110 mph. on a cushion of oil...

How can a bomber hit the dirt at 110 mph. without cracking up? The answer is partly in the design of its hydraulic landing gear. A cushion of oil, imprisoned between a cylinder and piston, absorbs the shock. The only seal which prevents escape of the oil is the precision with which piston and cylinder fit. Achieving the necessary microscopic accuracy is another of the many ways abrasives by Carborundum are helping to build our machines of war.

The interior surface of the landing gear cylinder is finished with a honing machine, as illustrated, fitted with abrasive sticks made by Carborundum. Similar honing machines are helping to produce engine cylinders, bearing races, and thousands of other products requiring an accurately finished internal cylindrical surface.





The future holds many possibilities for new uses of abrasives. When you take your place in industry, keep Carborundum in mind. The Carborundum Company, Niagara Falls, N. Y.

CARBORUNDUM
Reg. U.S. BRAND PAT. OFF.
ABRASIVE PRODUCTS

Carborundum is a registered trade-mark of and indicates manufacture by The Carborundum Company.

AN EXPRESSION OF FAITH IN AMERICA

RECENTLY, Goodyear dedicated a new home for its bold and manifold research activities, now concentrated on war products.

Gathered here, in vast array, are the most modern instruments of scientific discovery—not only in the fields of natural rubber, synthetic rubber and its kindred plastics—but in fields also ranging even to aerodynamics and metallurgy.

More than a million dollars went into this building and its equipment. It is, we believe, the finest laboratory for its purpose in the world.

But it is not the completion of the structure which we emphasize here.

It is rather the beginning of a new advance—an advance already launched by the limitless demands of war, which will surely gain momentum with the peace to come.

For Goodyear's growth has stemmed not from the accumulation of properties or from finance—but from fertility of the mind and the serviceability of the products which this fertility brought forth.

From the beginning Goodyear has steadfastly stressed research to advance the usefulness and value of its products.

It was this constant quest for improvement which, in the early days, originated the first straight-side tire.

It brought forth the first pneumatic tire for trucks and farm tractors—the first low pressure tire for airplanes.

It brought cotton, rayon and nylon cord tires to their high perfection.

It produced Pliofilm and Airfoam, twin advances in packaging and cushioning.

It developed the never-equaled Compass transmission belt.

It perfected bullet-puncture-sealing fuel tanks for airplanes.

It enabled America's first *all-synthetic* tire, produced by Goodyear in 1937.

And for 28 years now, it has won popular tribute, expressed in the fact that more people ride on Goodyear tires than on any other kind.

We cannot predict what this laboratory will bring forth in future.

But in the realm of possibilities—from the developments spurred by war—is such a range of products as nailable glass, wafer-thin insulating materials, hundred-mile conveyor belt systems, non-freezable plastic water pipes, metal-wood laminations for car and airplane bodies, mildewproof tents and awnings, static-free radio, all-welded airplane fabrication, crashproof airplane fuel tanks, and many like wonders on which we are now at work.

These will dictate in significant measure "the shape of things to come," forecasting the fullness of life which is ours to conceive and realize when peace returns.

So what we have dedicated is not a building, but the talents which this building is built to serve.

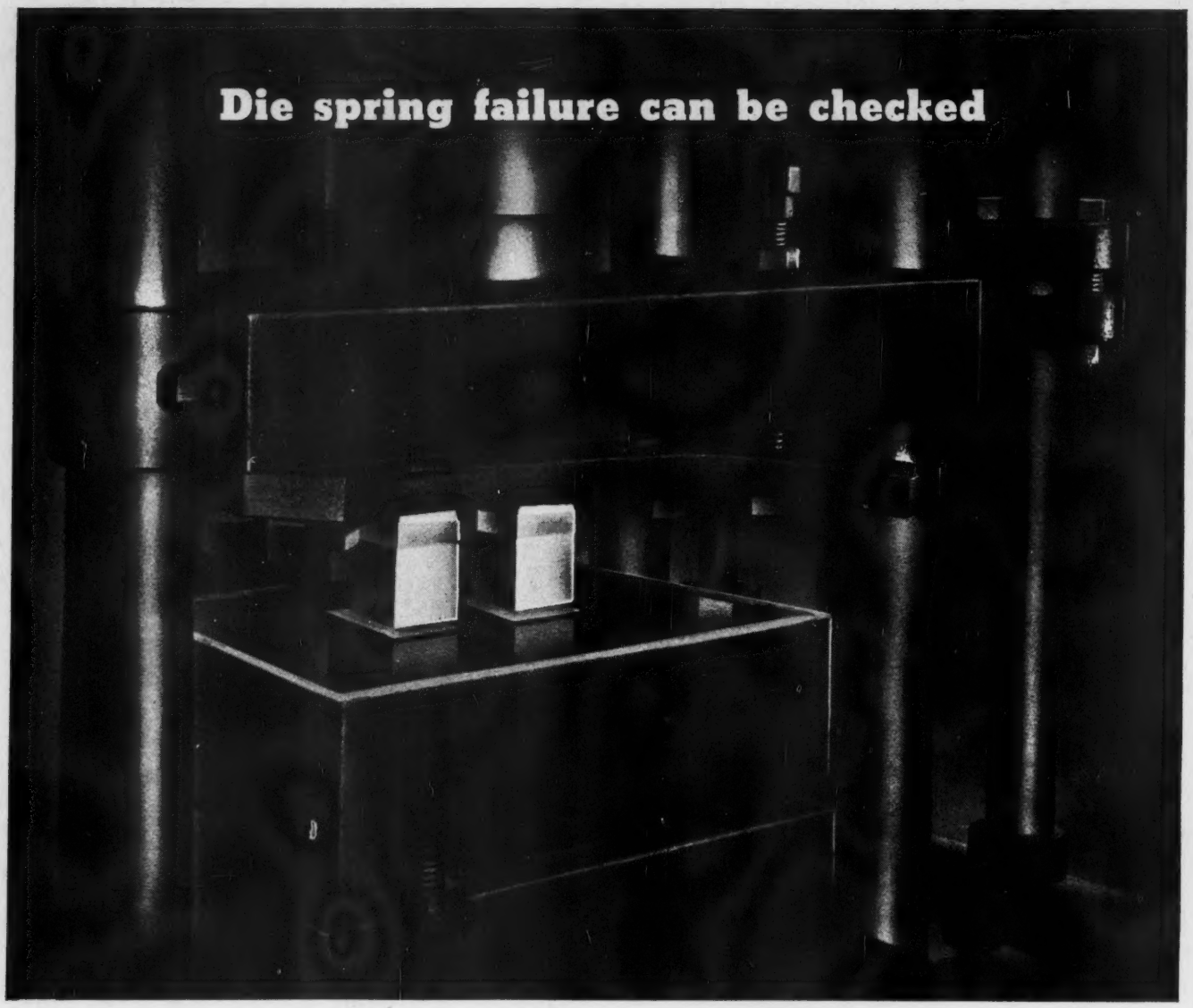
It is our aim to make it forever true of Goodyear, as of life in America, that "the best is yet to come."

Pliofilm, Airfoam, Compass—T. M.'s The Goodyear Tire & Rubber Company

GOODYEAR

THE GREATEST NAME IN RUBBER

Die spring failure can be checked



Information supplied by an Industrial Publication

A recent investigation of die spring breakage developed the following prominent causes:

1. Hydrogen embrittlement resulting from plating, pickling or cleaning.
2. Incorrect die design.
3. Incorrect spring size.
4. Speed of compression cycle.
5. Poor quality of wire.

There are, fortunately, remedies for all these conditions. Hydrogen embrittlement can be corrected by heating plated springs to about 450°F. and air cooling.

Faults in die design usually consist of either insufficient or too great clearance between the outside diameter of the spring and the guide hole. The clearance should be such that the spring operates freely, but has no chance to buckle.

Care should be taken in selecting springs to see that they are properly designed for both length of compression stroke and speed of compression. If springs are repeatedly compressed too close to their solid height, quick failure will result. The same is true where the rapidity of compression is too great.

It seems obvious that the quality of the spring wire should be commensurate with the job. Cheap wire should be avoided because of defects that are bound to cause trouble, especially when springs are plated.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

ARMY E NAVY

MOLYBDIC OXIDE, BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

Climax Molybdenum Company

500 Fifth Avenue • New York City

MOLY

THE TECH ENGINEERING NEWS

PROFESSIONAL JOURNAL OF THE UNDERGRADUATES
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Volume XXV OCTOBER 1943 Number 1

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BINOCULAR PRISMS

X-RAY METALLOGRAPHY

By ROBERT M. GOULD, 6-45
Art Editor, The Tech Engineering News

Pictures Courtesy M.I.T. Department of Metallurgy

X-RAY Metallography is the use of X-rays in testing metals. There are two methods of testing which are related only by the fact that both use X-rays. One is the Radiograph, using the penetration powers of the X-rays to form a picture; the other is the X-ray diffraction method, using the diffraction of metals to determine crystalline structure. These X-ray procedures have given the metalworker the only conclusive and practical test which he may apply to a finished product. Unlike laboratory or field tests, the X-ray, being non-disfiguring, non-weakening, and non-destructive, leaves the object tested in its original condition.

The metalworker, by using the X-ray, can check his material for defects before expensive machining and finishing have been done, thus saving time, money, and labor. The practices of machining and casting can be improved by examining X-ray pictures of pieces which have failed in service. The workman, who can see how the object with which he is working reacts to processing, can improve his technique.

The X-ray picture, or radiograph, is not only used for checking defects, but also allows the examination of the internal structure of a metal. The organization of the atoms can be seen. The atomic arrangement of alloys can be compared with those of the parent metal and the properties of the alloy predicted. Since anything done to an object leaves its mark on the atomic structure, any force that has been applied to a piece of metal can be determined.

Cast-iron sprocket. The points "A" are places where the metal is thin. Point "B" shows lack of fusion. Point "C" is a sand inclusion.

The use of X-ray diffraction, which has been proved to be the only non-destructive, conclusive way to measure residual stresses, is the newest application of X-ray metallography. It has been developed at M.I.T. by Professor John T. Norton and his associates.

The radiograph is really a shadow picture of the specimen. The penetrating powers of the X-rays permit them to pass through the metal without being completely absorbed. The degree of absorption depends upon the thickness of the material the rays must pass through. If the specimen is homogeneous, the image will be of uniform intensity, while any variation in the structure will be recorded below the specimen in the X-ray image. Because this image is invisible to the naked eye, however, some recording device is used usually a photographic film.

The parts of the photographic film exposed to the X-rays will, after development, appear darker than the rest of the picture. This degree of darkness is called the density. The density and the intensity of the rays are proportional to each other. By making tests with different intensities of the rays, the working range of the film can be found.

The contrast is the ability of the film to differentiate between two similar intensities. The success or failure of the radiograph depends to a large extent upon the contrast which can be increased by the use of intensifying screens. These screens consist of calcium tungstate crystals, on a cardboard backing, placed in contact with the film. When exposed to X-rays, the crystals fluoresce and emit a bluish light which has a strong action on the film. A combination of two of these screens with the film between them reproduces the X-ray image much more rapidly than the film alone.

In all these tests the standard hot filament type X-ray tube is used. It consists of an evacuated bulb, usually glass, with two electrodes. One of these is the hot filament, the source of electrons. It is usually composed of a spiral of tungsten wire. The other electrode is a block of metal, usually tungsten, which acts as a target for the electrons. The X-rays are produced when the electrons, traveling at a high velocity, are stopped by the impact with the metal atoms. The high velocity on the electrons is obtained by an intense electric field, which is produced by applying a high voltage to the

(*Continued on page 18*)

QUALITY CONTROL

By JOSEPH MANUELE, '25

Pictures Courtesy
Westinghouse Electric and Manufacturing Company

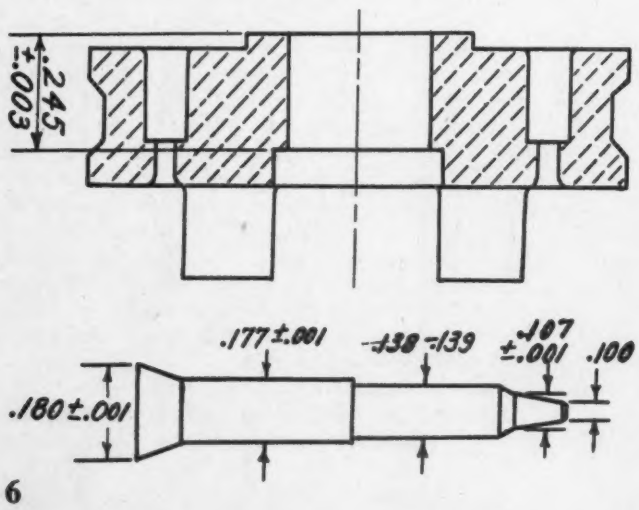
AN increase in production of as much as 30 per cent and a corresponding decrease in unit costs, without the addition of machine tool equipment or other manufacturing facilities, may result from the application of quality control to manufacturing operations. The increased production and lower cost may be obtained merely by an improvement in the quality of the product. The improved tooling and machine set-ups required to achieve the better quality will also result in further increased production.

In the ordinary manufacturing plant, inspection is a postmortem operation performed on parts after they are produced. The function of inspection is to compare parts to established standards, or specifications, and note any deviations. Those parts which meet the standards are accepted, or passed for further processing, and parts which do not meet the standards are rejected. Rejected parts are either corrected by the expenditure of extra work upon them, or scrapped. Inspection, as ordinarily practiced, is a screening operation performed to separate acceptable from unacceptable units; it contributes nothing to the value of the product, and does not improve the quality in any way.

When asked: "How much inspection is required to improve the quality of a product?" we are faced with the fact that "quality cannot be inspected into a product — it must be built into it." Therefore, we come to the obvious conclusion that no amount of inspection can improve the quality of a product. This is a sad blow to those old-line inspectors who still adhere to the principle of 100 per cent, or detail inspection.

Fig. 1. Molded part made in 16 cavity mold. The critical dimension .245" ± .033 must be maintained

Fig. 2. Part made in automatic screw machine. It costs more to inspect this part than it does to make it, when 100 per cent inspection is used.



This principle of 100 per cent inspection is satisfactory only from the customer's point of view. It is true that inspection protects the customer against receiving sub-standard products and in this manner may be said to create goodwill for the manufacturer. However, it must be recognized that the manufacturer might have to produce a much larger quantity of products than he sells, because, certainly, the products rejected by the inspection department cannot be sold, if the integrity and good name of the product are to be maintained. Inspection itself prescribes no preventive methods for reducing the number of defective units produced and, therefore, does not protect the manufacturer against loss due to the scrapping or reworking of defective units.

An added loss is the restriction placed on potential productive output because if an operation is producing 10 per cent unacceptable parts, it is the same as if only 90 per cent of the potential productive output were being obtained.

Quality Control is the name applied to a modern technique which complements the usual inspection procedure and focuses a spotlight on the existence of unfavorable conditions before evidence that difficulties are developing would otherwise become available. It puts inspection closer to the beginning of the manufacturing cycle and determines:

(*a*) Will defective parts be produced by this set-up and tooling?

(*b*) What is the cause for the production of these defective parts?

Quality control principles, properly applied, go beyond the mere inspection operations by actually eliminating the production of defective parts.

There are three general methods in quality control and each has its particular application in order to insure the production of parts which are acceptable in every respect:

(*a*) Statistical analysis to answer the question: "Can it be made?" This method is generally followed by the application of either method (*b*) or (*c*), depending on circumstances.

(*b*) Control chart method — generally applied to continuous operations and on parts which have to be made to extremely close tolerances.

(*c*) First-piece and patrol inspection — has a very

About the author:

Joseph Manuele was born in Sicily, Italy, in 1897. When he was eight years old he came to the United States and has never left this country since. He graduated from Massachusetts Institute of Technology in 1925 with the degree of Bachelor of Science in Electrical Engineering, and immediately entered the graduate student course of the Westinghouse Electric and Manufacturing Company. He joined the inspection department in 1926 and worked for four years in the shop, when in 1930 he was called to the Inspection Headquarters staff where he is now Director of Quality Control.

A member of the American Society of Mechanical Engineers and the American Institute of Mathematical Statistics, Mr. Manuele has published articles in many national technical and engineering magazines.

wide application and can be used on tooled operations and on hand operations.

A good application of statistical analysis is the molded part shown in Figure 1. This part is made in a 16-cavity mold and considerable difficulty was being experienced in maintaining the .245″±.003 dimension. Therefore, the first step was to determine whether the part could be made.

Thirty-three pieces were taken from each cavity and carefully measured. From these measurements the average, ($\overline{X}$), of the pieces produced by each cavity was calculated. The standard deviation, (σ), was also calculated. These two statistics, for eight cavities, are shown in Table I. (The entire tables are not shown in order to conserve space.)

Remembering that according to the normal curve 99.7 per cent of the parts will be produced within the limits $\overline{X}\pm3\sigma$, we find that the parts are being produced within the proper tolerances (3σ is smaller than .003″ for each of the cavities), but $\overline{X}$ is too far from the drawing nominal dimension (.245″) in every cavity. This means that the part can be made within the tolerances required, but the individual mold cavities must be adjusted to bring the average of each cavity to .245″; cavity No. 1 will have to be closed .0021″, cavity No. 2 will have to be closed .0085″, and so on.

TABLE I

The Average and Standard Deviation of 33 Parts Produced in Each Cavity Before Correction to Mold

	No. 1	*No. 2*	*No. 3*	*No. 4*
$\overline{X}$	.2471	.2535	.2579	.2573
σ	.0009	.0009	.0010	.0006
3σ	.0027	.0027	.0030	.0018
	No. 5	*No. 6*	*No. 7*	*No. 8*
$\overline{X}$	.2559	.2599	.2576	.2542
σ	.0008	.0007	.0005	.0006
3σ	.0024	.0021	.0015	.0018

TABLE II

The Average and Standard Deviation of 50 Parts Produced in Each Cavity After Correction to Mold

	No. 1	*No. 2*	*No. 3*	*No. 4*
$\overline{X}$	.2444	.2446	.2442	.2460
σ	.0006	.0005	.0009	.0009
3σ	.0018	.0015	.0027	.0027
	No. 5	*No. 6*	*No. 7*	*No. 8*
$\overline{X}$	.2454	.2461	.2444	.2442
σ	.0008	.0008	.0009	.0007
3σ	.0024	.0024	.0027	.0021

Table II shows the average and standard deviation for 50 pieces produced in each of eight cavities after the mold was corrected. This shows that the operation should produce parts which are all satisfactory. A detail inspection of 1,000 parts revealed no rejections; an inspection of 10 per cent of a subsequent lot of 6,000 parts also failed to reveal any defective units.

As a result of this investigation and mold correction, a counterboring operation was eliminated, thus materially reducing the cost of the part; the detail inspection of all parts was also eliminated, thus materially reducing the cost of inspection; also the full productive capacity of the operation is now being utilized as all parts produced are acceptable. From this point on, only an occasional floor inspection, to guard against mold wear, is required to insure the continued production of satisfactory parts.

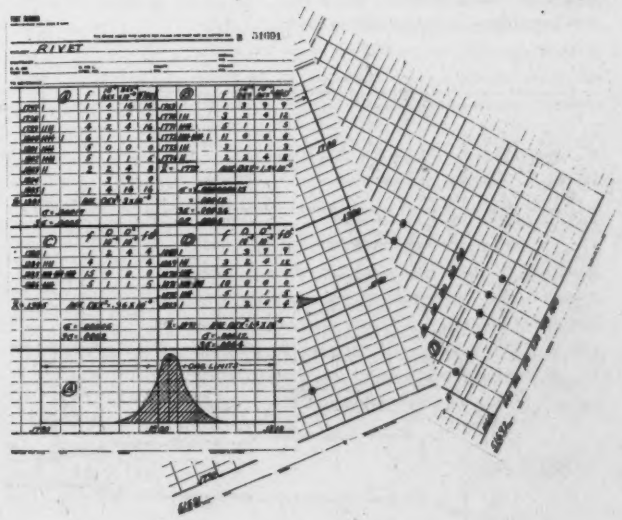
The control chart technique differs very little from the statistical analysis method. The original inspection and calculations are the same. Figure 2 shows a typical part to which the control chart technique has been applied. Table III shows a small cross section from the production history of this part. It will be noted that an average of 22.3 per cent of the parts inspected during this period were rejected. Another striking fact is the variation in the percentage of defective parts produced from day to day.

Figure 3 shows the work sheets used in establishing statistical control over this item. A sample of 25 pieces was taken and each of the four critical dimensions was measured. From the measurements, the average, ($\overline{X}$), and the standard deviation, (σ), for each dimension were calculated. The machine set-up was adjusted and the cutting tools were dressed until $\overline{X}$ was very close to the nominal drawing dimension, and three times the standard deviation, (3σ), was less than one-half the drawing tolerance. The control chart limits were set at $\overline{X}\pm3\sigma$. These limits were well within the band determined by the drawing tolerances.

Figure 4 shows a typical control chart used for controlling the quality of parts which must be made to small tolerances. The chart is also a complete log of what was done to the machine and the tools during the running of the job. The chart shows that a good machine set-up will run for 15 to 20 hours continuously without requiring any adjustments, or dressing of tools. It is

(*Continued on page 22*)

Fig. 3. Typical work sheets showing the preliminary analysis and calculations for the establishing of a control chart.



PEACETIME SALVAGE...

By DOCTOR WILLIAM DAVID COOLIDGE, '96

General Electric Company

Dr. Coolidge in his laboratory

BENDING LIGHT .

A new sandless glass has light-bending properties which make it superior to ordinary glass for many types of lenses.

PHOTOGRAPHY

A mercury lamp the size of a cigarette, which can be operated on a household circuit, makes possible pictures with an exposure of 1/1,000,000 of a second.

100,000,000 VOLT X-RAY

Dr. Coolidge's laboratory has announced that on August 21 of this year they succeeded in producing 100,000,000 volt X-rays for the first time. They were obtained from the large induction electron accelerator which was recently completed.

TODAY the majority of the scientists of the country are devoting their entire energy at high pressure to war work, and we see science playing so vital a rôle that it alone may win or lose the struggle.

While this war, which has forced the diversion of so much scientific effort from the constructive aims of peace to the destructive aims of combat, represents in magnitude the greatest tragedy which civilization has ever encountered, much of the war work will have lasting value, and in many important lines research is being prosecuted at a rate which would be quite out of the question in peacetime. This is especially true in the fields of physics and chemistry. Most of this work is of so confidential a nature that it cannot be publicly discussed at this time.

In the X-ray field I can say that until within the last two years but few radiographs have ever been made using more than a couple of hundred thousand volts. As a result of the war, industry is now employing many one-million volt radiographic outfits. These are portable and mechanically and electrically flexible, and permit the ready examination of steel castings and welds up to a thickness of as much as eight inches.

The arguments in favor of using X-rays of such high voltage are as follows: First the penetrating power increases rapidly with voltage and is enormously greater at a million than at the fifty or sixty thousand volts used, for example, in intra-oral dental work. Then the increased penetration reduces contrast and so makes it possible to depict on the same film both the thick and the thin portions of an object of irregular shape and variable thickness. Finally the scattering of the X-rays in the material being radiographed, which tends to blur the picture, gets less and less troublesome with increased voltage.

When the X-ray work of our

MARINE POWER

High steam pressures and temperatures in marine engines effect a saving of up to 40 per cent in fuel per horsepower-hour, thus increasing the range and striking power of United States Navy warships.

GLASS BEARINGS

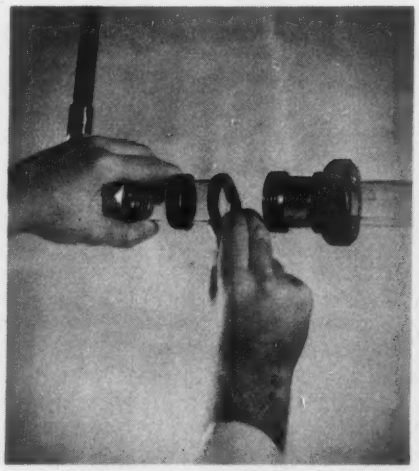
Glass "jewels" are today proving to be highly efficient replacements for scarce sapphires as bearings in electrical instruments.

RADAR . . .

TELEVISION . . . .

MACHINE TOOLS

Powder metallurgy produces new dies of tool steel composition which are better and cheaper than the ones they replace.



Corning Glass Works Photo

Glass pipes

from Wartime Research

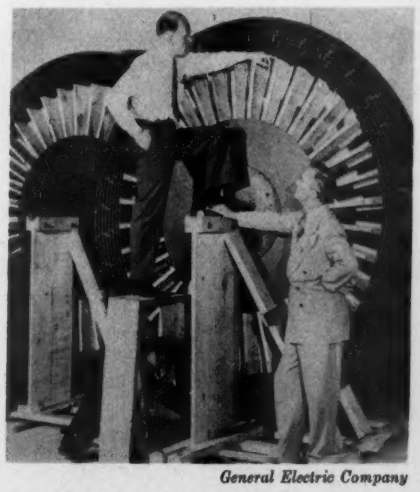
T.E.N.'s "Alumnus of the Month"

IMPROVED CONCRETE
Addition of small amounts of pine resin improves the resistance of highways and airport runways to freezing and thawing.

POWER CONTROL
Electronic device cuts off short-circuited power lines automatically.

WATERPROOFING
Chemical vapor process makes even paper water-repellent.

HEAT INSULATION
Four inches of glass wool provides the same insulation as fourteen feet of concrete.



General Electric Company

100,000,000 volt induction electron accelerator

laboratory started about thirty years ago, it was difficult to produce X-rays of much more than a hundred thousand volts.

We now have over forty one-million-volt outfits in use in war industries and are preparing to build a two-million-volt outfit of the same type.

Furthermore, we have recently built, with the help of Dr. Donald Kerst, of the University of Illinois, an induction electron accelerator for twenty million volts, and have now finished a larger one designed to operate at voltages up to a hundred million. This last device, used as a source of X-rays, should enable us to determine what radiographic and other useful results can be accomplished by such high-voltage radiation.

This same device will also render available for physical, chemical, and medical experimentation cathode rays corresponding to these same enormous voltages. In the medical field these cathode rays may have a good deal of therapeutic interest, since they will have sufficient penetration and since, unlike X-rays and gamma rays, their effect will be a maximum near the end of their range.

The fluoroscopic application of X-rays is also being developed rapidly for use in industry, where it makes possible the ready examination of small metal castings. Without this nondestructive method it has sometimes been necessary to expend much machine work on a casting before a fatal hidden defect was revealed. Such wastefulness of labor is now avoided by the fluoroscopic inspection.

In the medical field we have seen an X-ray development come to fruition during this war which will have great permanent value. It consists, in the photography with the camera on a smaller scale, of the fluorescent screen image and, in the case of chest examinations, it

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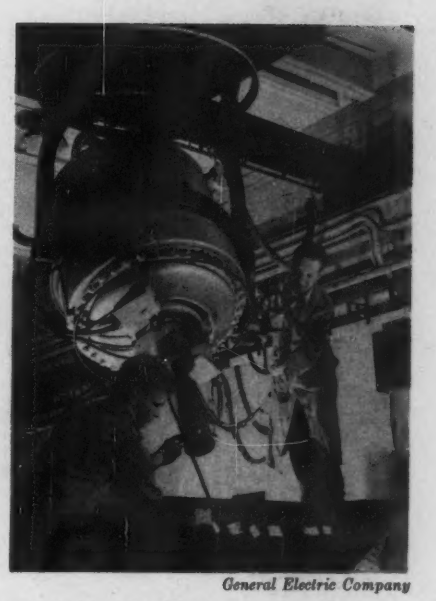


General Electric Company

1,000,000 volts X-ray steel

ORE RECLAMATION
Electrolytic process salvages manganese from low-grade ores.

CYCLONITE . . . TNT PLUS
Cyclonite, a new explosive developed by Dr. Alberto F. Thompson of M.I.T., explodes even faster than TNT.

WELDING
Critical aluminum is being saved by the use of atomic hydrogen for its welding.

SPEECH RECORDER
A spool of steel wire no bigger than a doughnut can record 66 minutes of continuous speech, and can be reused after a simple, demagnetizing process.

RESEARCH FOR VICTORY

By CARROLL W. BOYCE, 10-44
General Manager, The Tech Engineering News

Bell System Pictures

WITH so-called "critical" materials becoming harder to obtain and, at the same time, in greater demand, many of the most brilliant research men in America are bending every effort to develop substitutes and to devise new material-saving methods.

To aid in this critical salvage process, the ingenuity of every man and woman in the United States has been invoked by the Government. A national committee has asked for suggestions from every citizen, and has already received over 50,000, many of which have resulted in the saving of millions of dollars in time and critical materials. This same plan is being used in many large companies, but the great bulk of progress has originated in the large research laboratories.

In this latter field one of the leaders has long been the Bell Telephone Laboratories. Besides the large volume of secret work which the laboratories have undertaken for the armed forces, the men of the laboratories are constantly striving to find ways of saving war-vital materials. As it is metals which are, perhaps, the scarcest items, it is the work of the Laboratories' Metallurgical Department which is most apparent.

One of the most publicized achievements of this department was the development of fillet wiped soldered joints. This permits a great reduction in the amount of solder placed on a wiped joint between the cable sheath and sleeve. Instead of the full sized wipe (Figures 1 and 2), a wipe of fillet proportions is made (Figure 3). Through this change, more than 60 per cent of the solder ordinarily used in cable splices is saved. In a normal year's construction this would represent a saving of 600,000 pounds of tin alone, and proportional amounts of lead and arsenic. (Composition of solder for wiping joints is approximately 38 per cent tin — 61.9 per cent lead — 0.1 per cent arsenic.)

Another material and labor-saving feature of this fillet wiped joint is that the metal cools faster and more uniformly, thus reducing failures in the field. This removes the necessity of replacing splices as frequently and also thus eliminates many of the cable failures which interrupt vital cable service. It also requires less skill on the part of the splicer and saves valuable time in training.

When the men of the Labs encountered the problems of producing very fine platinum wire they turned to the vacuum casting induction furnace. It was found that tiny air holes in the metal of this super-fine wire were leading to failures, so the vacuum furnace was resorted to, and this satisfactorily eliminated much of the difficulty. This furnace permits turbulent melting of the metals in a sealed crucible with a pressure as low as 0.01 mm. of mercury. A schematic diagram of this device, the many applications of which are daily speeding the war effort, is shown in Figure 4.

(*Continued on page 14*)

Fig. 1. Conventionally wiped joint between telephone cable and sleeve.

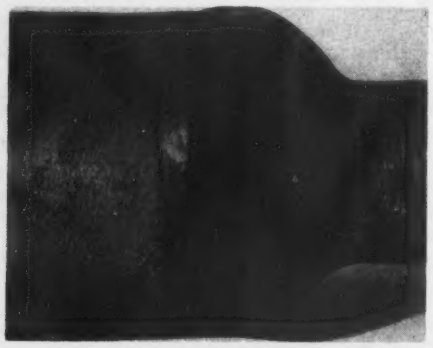


Fig. 2. Section from joint wiped conventionally. ×1½

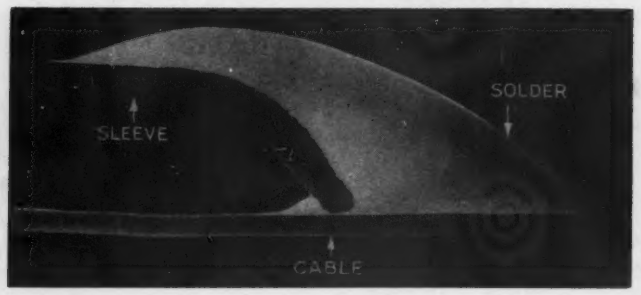
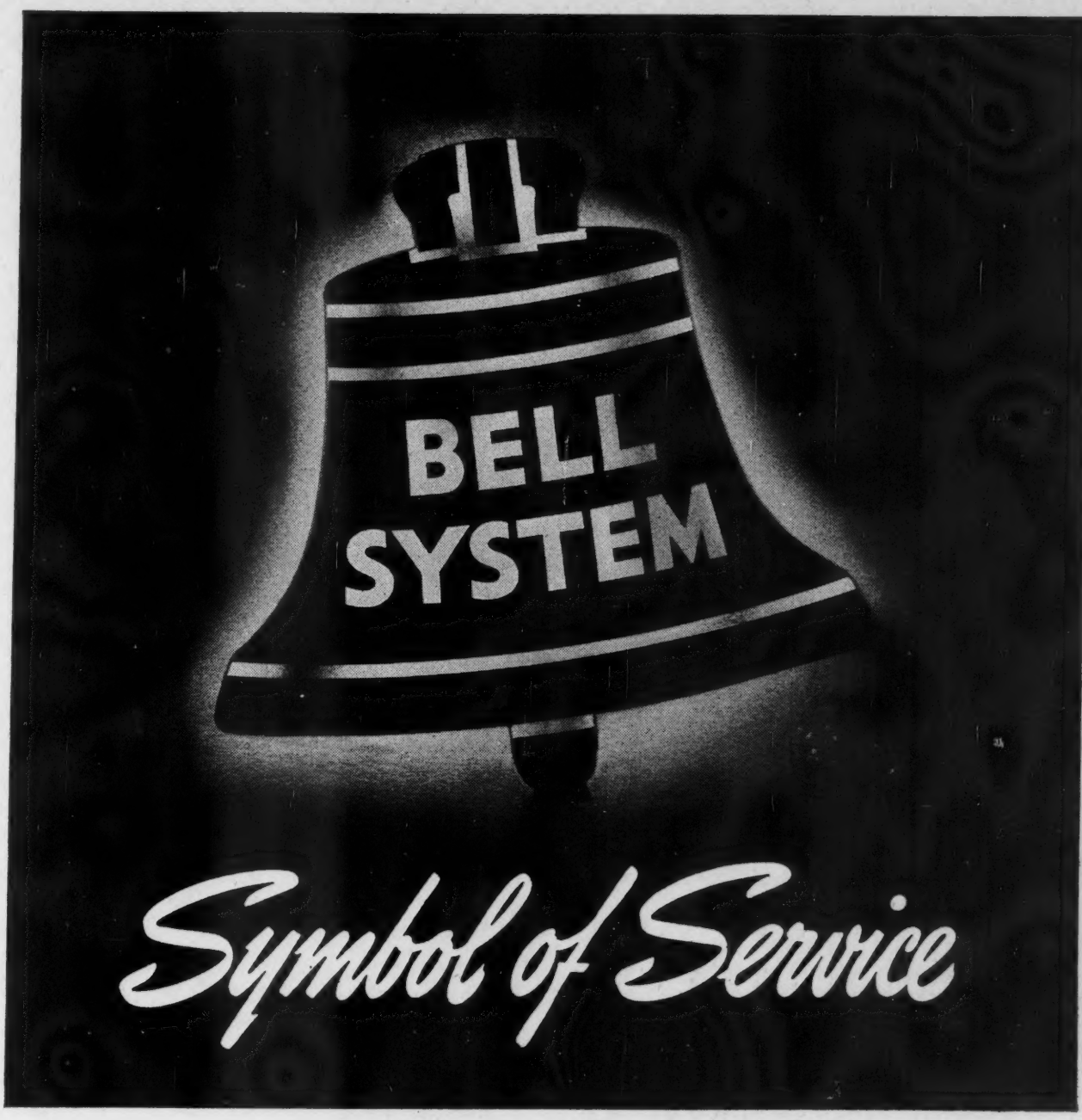


Fig. 3. Section from joint wiped by fillet technique. ×1½



. . . in peace and war

This emblem is familiar throughout the nation as the symbol of a well-trained team, integrated for service in peace or war—The Bell Telephone System.

1. American Telephone & Telegraph Co. coordinates all Bell System activities.
2. Twenty-one Associated Companies provide telephone service in their own territories.
3. The Long Lines Department of A. T. & T. handles long distance and overseas calls.
4. Bell Telephone Laboratories carries on scientific research and development.
5. Western Electric Co. is the manufacturing, purchasing and distributing unit.

The benefits of the nation-wide service provided by these companies are never so clear as in time of war.

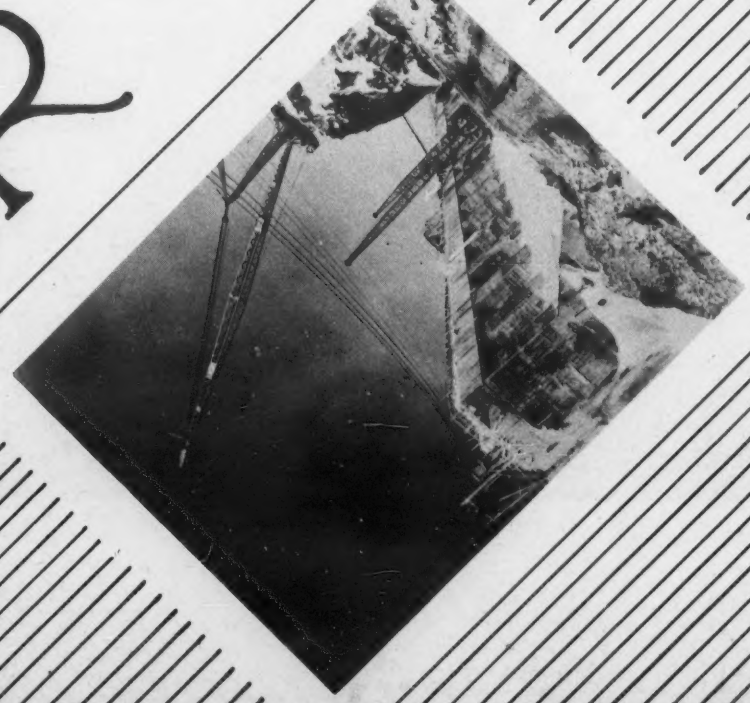
★ ★ ★ ★ ★ ★

POWER IN THE

Located on the upper waters of the Saguenay River in Quebec, the $65,900,000 Shipshaw project will provide, for vital war production, power comparable to that of Boulder Dam. Men worked through the last two winters, often in temperatures as low as 40 degrees below zero, and the whole project is scheduled for completion this year.

Pictures Courtesy
General Electric Company

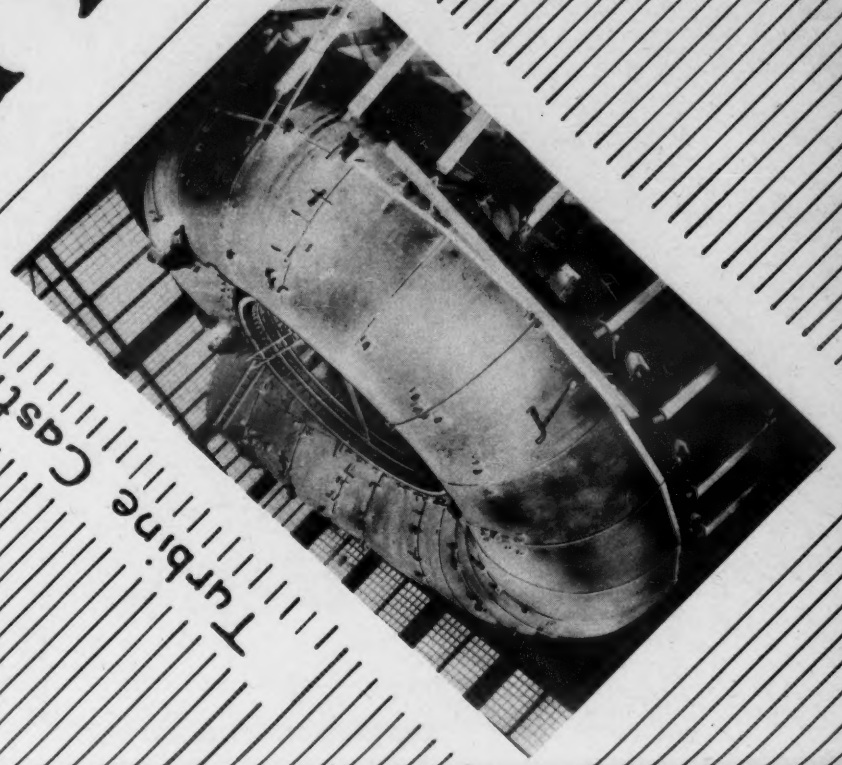
15,000 KVA Stator



Water Gates

CANADIAN WILDS

Cover for 90,000 H.P. Winter View



Turbine Casting

RESEARCH FOR VICTORY

(*Continued from page 10*)

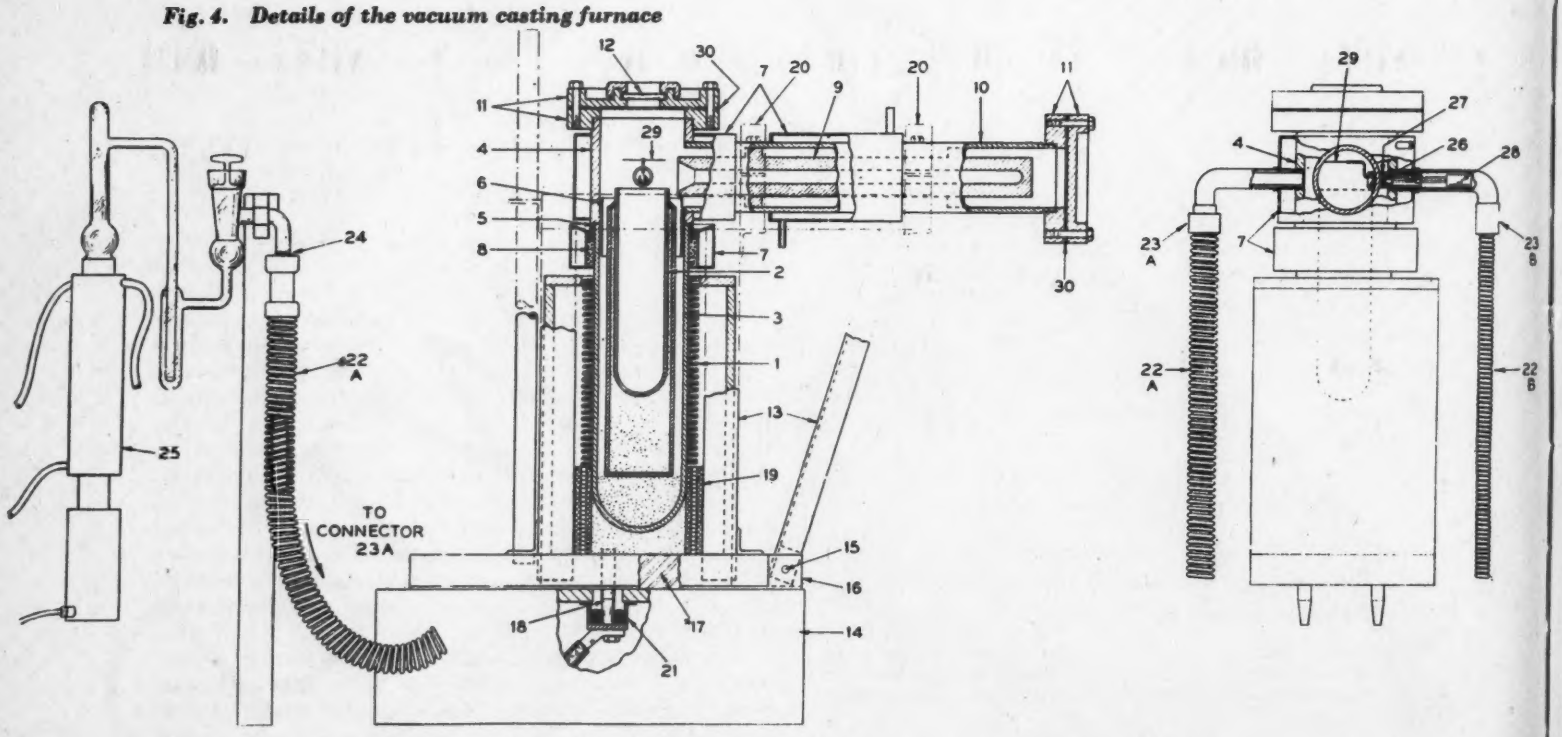
To facilitate the investigation of magnetic materials and contacts, some of which must give satisfactory performance through 150 million operations, it was found desirable to roll alloys into very thin sheets. For this reduction, the Laboratories now use a specially designed 20-roll cold-reduction mill, equipped with small diameter working rolls, each backed with a cluster of nine supporting rolls (Figure 5). This set-up permits unit-pressures high enough to roll a sheet of metal only a fraction of a mil thick.

Fig. 5. Small, precise, cluster mill for rolling thin sheet metals for experimental studies

A development which was occasioned originally by purely economic motives before the war, but which now assumes even greater importance because of the savings it makes possible in metals was the introduction of Permalloy in loading coils and filter coils. Relative weight savings of 10–20 or more to one can be effected by using 120-mesh Permalloy, the particles of which are, before pressing into cores, insulated with a high resistivity, heat resistant material. The presence of a few thousandths of one per cent of sulphur in the alloy (about 80 per cent nickel, 20 per cent iron) causes a structure which can be rolled to small sections when hot, and yet, when cooled, becomes exceedingly brittle and lends itself very well to pulverization. The most difficult part of the process is controlling the amount of manganese which is added to increase resistivity and improve the magnetic properties, but which has an effect opposite to that of the sulphur.

The nature of the work now being attacked by the Laboratories is not a matter of public discussion, but one project on which research was being done at the outbreak of the war which seems to offer great possibilities was on coaxial cables. These cables are used for the new million cycle transmission systems. It was such a cable that was used for transmitting the telecasts of the 1940 Republican Convention from Philadelphia to New York. But if coaxial cables are to be the medium of inter-city television distribution after the war, it will probably be necessary to reduce the cost considerably. This might take the form of a revised transmission method, or simply a revision of coaxial cables along lines of greater economy. Whatever is done in the television field, though, it seems safe to assume that the Bell Telephone Laboratories will be among the leaders in the field of those producing new developments.

Fig. 4. Details of the vacuum casting furnace



1 - INDUCTION COIL
2 - CRUCIBLE
3 - SILICA TUBE
4 - STEEL HEAD
5 - CEMENT JOINT
6 - REFLECTOR
7 - WATER JACKETS
8 - ZINC CEMENT
9 - MOLD
10 - SEAMLESS STEEL TUBE
11 - FLANGES
12 - PYREX GLASS WINDOW
13 - CRADLE
14 - TABLE
15 - STEEL AXLE
16 - ANGLE IRON
17 - ALBARENE STONE
18 - INDUCTION COIL TERMINALS
19 - TRANSITE CYLINDER
20 - ALUMINUM CLAMPS
21 - MERCURY CUPS
22 - SEAMLEX TUBES
23 - CONNECTORS
24 - PICEIN WAX JOINT
25 - GAEDE PUMP
26 - ADDITION MATERIAL
27 - NICKEL TUBE
28 - PLUNGER
29 - MICA SHIELD
30 - LEAD GASKETS

THE EDITOR HAS THE D.T.'S

(MENS IN ABSENTIA)

— A Very Unofficial Editorial —

There comes a time in the life of every editor when, despite his most valiant efforts, he finds it impossible to follow a rational pattern of thoughts. And when this happens, the editor always wishes he might indulge his wildest flights of fancy. To prove to any who have doubts that this should not be done, the following is what resulted when this editor, believing that editorial writing, like anything else, is an "experimental science," took the lid off.

Many electrical engineers seek to reduce everything to terms of electricity and electrical analogies. So perhaps it is only natural that a student of the art should seek the same goal.

This being the season of the Inter-Fraternity dance, it seems only fair that some evaluation should be made of its worth as entertainment. Denoting this "entertainment value" by E, the analogy is at once apparent, and the equation is seen to be:

$$E = L\frac{dx}{d\pi} + Rx + S\int x\,d\pi$$

L(Love). This has two components, the more important usually being the real part, although in extreme cases the imaginary part, which is always dangerous, takes precedence. The function may be represented by

$$L = \frac{4\pi\mu s}{l} + j\omega(WB)$$

in which

π = Passion.
s = Sweetness. (Do not confuse with S.)
μ = Permitivity.
l = Likeness of interests of the two parties.*
$\omega = 2\pi$ times frequency of dates.
W = Wealth of male party.
B = Relative beauty of female party.

R(Relaxation). This function may be conveniently defined by the relation

$$R = \frac{M}{Ci^2}$$

C = Concentration of chaperones.
i = Illumination in lumes per square meter.
M = Relative quality of the music.

* While this factor is not indicative in all cases, in the large number of case histories studied, it was found that its accuracy was 97.54 per cent, as determined for Tech men by the probability integral

$$\frac{2}{\sqrt{\pi}}\int_0^x \epsilon^{-x^2}\,dx$$

in which x is a function of experience as used in the text.

S(Susceptibility). This likewise is simply defined, the relation being

$$S = \frac{Q_a v}{i^2}$$

Q_a = Quantity of alcohol present.
v = Velocity of consumption.
i = Illumination as before.

Checking this equation against the results obtained by Tech students and their guests in the I.F.C. Laboratory, a highly satisfactory agreement, both scientific and personal, is found. The only major discrepancy from assumed equation was found in the last term. Empirically, the term was definitely established as an exponential. The other factors missing in this term, which may also be readily determined by observation, are the limits of integration. This corrected, the term reduces to

$$\int_{\text{Wellesley}}^{\text{Tech}} S\epsilon^{s}\,d\pi$$

Just as to the electrical engineer it is at once apparent that it is not simply voltage, but the product of voltage and current, or power, which is, in the final analysis, the important item, so to the entertainment engineer it is evident that it is not entertainment value alone, but rather the power of mutual attraction which is, in the long run, of paramount importance. (Hereafter this shall be denoted by P_m.)

Once again the electrical analogy is useful, giving immediately

$$P_m = EI_m$$

in which I_m is the mutual interest. For the parties involved to make an accurate determination of this factor is extremely difficult, as they have only each other's word on which to base calculations of a numerical value. However, this factor can be compensated for, as is seen by extending the analogy to include the proper trigonometric function of the angle θ. It remains now only to determine the proper function. For the real part of P_m the function is the cosine of the angle, so for the maximum, θ should be small. The imaginary part is obtained by introducing the sine of θ. For the benefit of those not conversant with electrical terminology, it should be noted that $EI_m \sin\theta$ is known as the "reactive" power, so when dealing with particularly angular females, where θ is large, extreme caution should be exercised.

For those who may wish to conduct further experiments to check on the validity of these data and equations, it should be stated that operating conditions are not easy to obtain, so if the conditions do become ideal, do not hesitate to take advantage of them as they may be very hard to duplicate.

C. W. B.

Bigger Round-ups f

A-C equipment helps speed meat through packing plants—helps dehydrate foods so each ship can carry 10 times more.

How Allis-Chalmers, one of U. S. A.'s most unusual companies, produces Tractors and Farm Machinery . . . Generators, Turbines, Drives for War Plants . . . 1600 products to help Feed the World and Lick the Axis.

FEW OF OUR WORKERS have seen a Texas or an "Axis" round-up . . . yet they *are* helping to put beef on soldiers' plates, prisoners in Allied stockades.

They make the world's largest variety of *farm* and *war-industry* equipment . . .

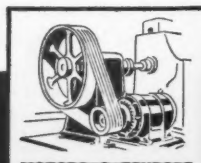
—Tractors, corn pickers, harvesters . . . equipment for dehydrating and processing foods . . . crushers for mines; switchgear for steel mills; motors for war plants . . . even hull sections for ships.

And A-C engineers—in factories all over America—are helping to increase production, not just with new machines *—but with machines already on hand.*

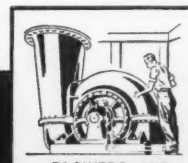
ALLIS-CHALMERS MFG. CO., MILWAUKEE, WIS.

ELECTRICAL EQUIPMENT

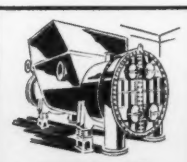
STEAM AND HYDRAULIC TURBINES



MOTORS & TEXROPE V-BELT DRIVES



BLOWERS AND COMPRESSORS



ENGINES AND CONDENSERS

CENTRIFUGAL PUMPS

FLOUR MILL E

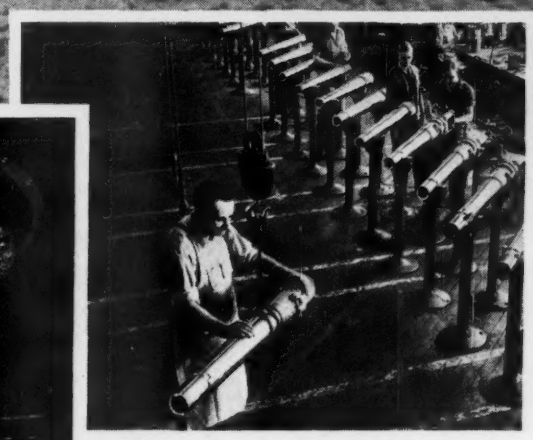
A-C ALLIS-CHALMERS MILWAUKEE

ALLIS-CH A

SUPPLYING THE WORLD'S LARGEST LINE OF

s for '43_

. . . . AXIS BULLIES



(*above*) **A-C equipment** — motors, belts, drives—keeps all types of guns moving along U. S. production lines.

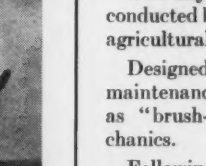
(*left*) **Huge A-C crushers** like this one munch iron ore, and other A-C equipment helps turn it into steel.

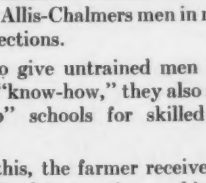
FLOUR AND SAW MILL EQUIPMENT

CHEMICAL PROCESS EQUIPMENT

CRUSHING, CEMENT & MINING MACHINERY

BOILER FEED WATER SERVICE


POWER FARMING MACHINERY


INDUSTRIAL TRACTORS & ROAD MACHINERY

HALMERS

INE OF MAJOR INDUSTRIAL EQUIPMENT

WE WORK FOR VICTORY — WE PLAN FOR PEACE

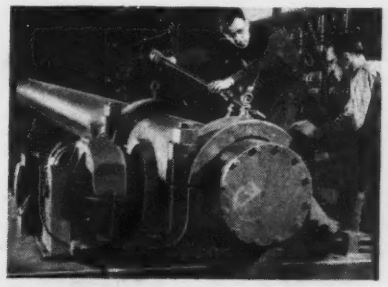
VICTORY NEWS

A-C Launches Farm Commando Plan: A large share of America's farm equipment will soon be brought to peak efficiency through Allis-Chalmers' new "Farm Commando" program.

Two-day mechanic schools are being conducted by Allis-Chalmers men in many agricultural sections.

Designed to give untrained men basic maintenance "know-how," they also serve as "brush-up" schools for skilled mechanics.

Following this, the farmer receives detailed, specialized instruction on his own equipment. Special red-white-and-blue emblems are provided for his machines to announce that each of them is a "Farm Commando, Ready to Roll . . ."



Not A Gun, but an Axis buster nevertheless! This huge tool is used in A-C shops to bore out the inside of kilns. It helps increase production of manganese.

British Ask For A-C Booklet: A sign that British industry currently cocks an eye at vital maintenance, comes in the form of a request from a representative of the Electrical Advisory Panel. To "tell all" about motor care in wartime, our Allies will pattern their information after Allis-Chalmers' "Guide to Wartime Care of Electric Motors." This booklet has already been widely distributed in the U.S.A. *Write for your free copy today.*

FOR VICTORY

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X-RAY METALLOGRAPHY

(*Continued from page 5*)

electrodes. Simultaneously a low voltage is used to heat the electrodes.

When operating on low voltages the tube acts as its own rectifier, because current will run through it in only one direction. Extremely high voltages can be used without separate rectifiers by placing a grid in the X-ray tube, thus increasing its rectifying qualities.

The beam of X-rays has two important characteristics, the intensity or quantity, and the wave length or quality. The intensity is controlled by the temperature of the hot filament and is measured by the current flowing to the tube. The wave length of the beam, determining the penetration power of the rays, is controlled by adjusting the voltage supplied.

The intensity of the radiograph is determined by several conditions. It depends upon the intensity of the X-ray beam itself — the greater the beam, the greater the intensity of the image. It is inversely proportional to the square of the distance between the source of the rays and the film. It is also dependent upon the thickness and the nature of the material being tested. Changes in intensity due to variations in thickness are dependent upon the voltage used. Small changes in thickness with a low voltage produce a larger change in the image than the same change in thickness would produce with a higher voltage. Thus it is the usual practice to use as low a voltage as will produce the necessary background density. The magnitude of the smallest detectable defect is called the sensitivity. It is determined by the sharpness or detail of the image and the density difference.

A radiograph, to be of any use, must have certain characteristics. It must be free from distortion, or deformation of shapes. There must be good resolution or definition. There should be no chemical stains or misleading surface marks caused by extraneous matter on the film. The picture should have sufficient contrast in tones to enable the viewer to distinguish between varying photographic densities.

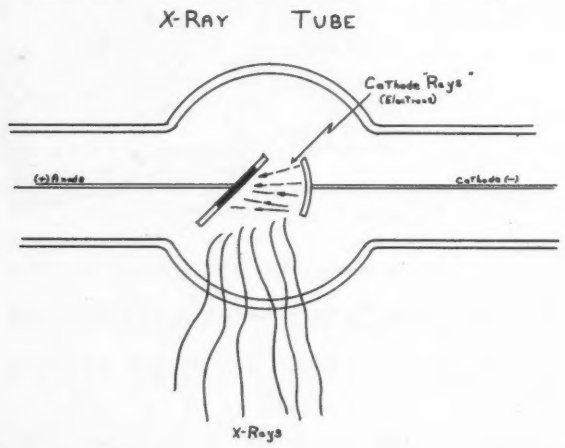
The flaws seen in a radiograph are usually classified under the following headings:

Void: a local area of total vacuity. An area containing gases is not termed a void.

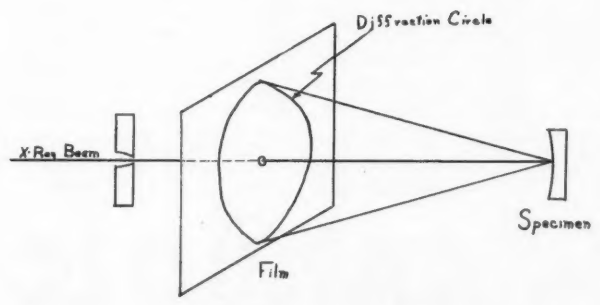
Blowhole: a defect of gaseous origin which tends to open to the surface.

(*Continued on page 28*)

X-ray tube showing construction. The X-rays are being formed when the electrons hit the target.

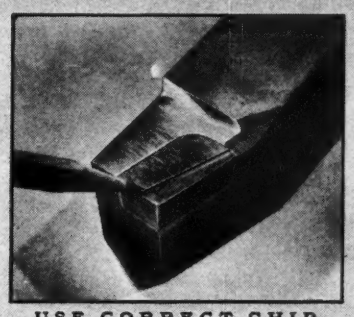


The principle of the X-ray defraction method. The distance between circles would tell the strain in the specimen.

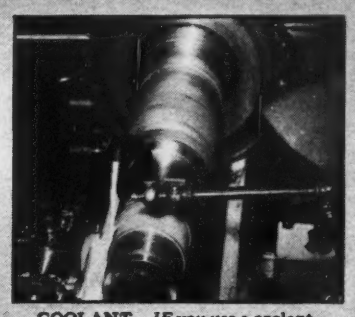


6 STEPS TOWARD TOP PERFORMANCE, WITH CARBIDES, WHEN YOU *CUT STEEL*

CUT AT HIGH SPEEDS—For top performance on the average steel-cutting job, don't cut at speeds less than 200 *feet* per minute. Slow speeds often cause failure.



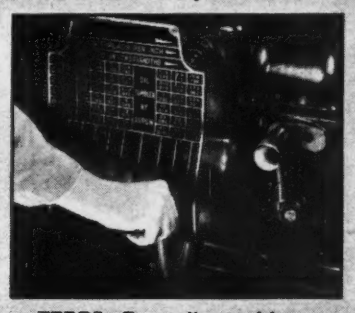
USE CORRECT CHIP BREAKER—When you break chips, break them right. Fit breaker to the job. The ground-in step-type shown is usually best.



COOLANT—*IF* you use a coolant, provide a heavy, continuous stream, preferably under pressure. If you can't provide ample coolant, it is better to cut dry.

KEEP TOOLS SHARP—Avoid running tools until excessively dull. This causes breakage or drastically shortened tool life. Grind tools at regular intervals for best results.

PROVIDE RIGID SET-UP—Keep tools at absolute minimum overhang necessary to clear work. Chuck part firmly. Rigidity is important with carbides.



FEEDS—For medium and heavy cuts on steel, use feed not less than .010" per revolution, and preferably .015" to .025". Light feeds "rub" tool, causing rapid dulling.

● Important in getting top performance, when cutting steel with carbides, are the six steps shown above. When correctly applied, carbide tools produce results far surpassing the performance of ordinary tools. They operate at machine speeds as high as 4 to 5 times faster than ordinary tools, stay sharp up to 10 times longer, and increase output often as much as 300%.

Important, too, is the carbide you use. When you select from the complete line of carbides produced by Carboloy Company, you get the best type for your particular job—whether it be the popularly designated "titanium carbides", "tantalum carbides". "tungsten carbides"—or "tri-carbide" grades.

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ALUMNUS OF THE MONTH

DR. WILLIAM D. COOLIDGE, '96

Vice-President and Director of Research
General Electric Company

William David Coolidge entered the Massachusetts Institute of Technology in the Class of 1895 with two other famous men, Gerard Swope and Alfred Sloan, but due to illness he did not receive his B.S. degree till 1896, soon after which he received his Doctor's degree from the University of Leipzig, writing his thesis on a method for making short wave radio waves visible.

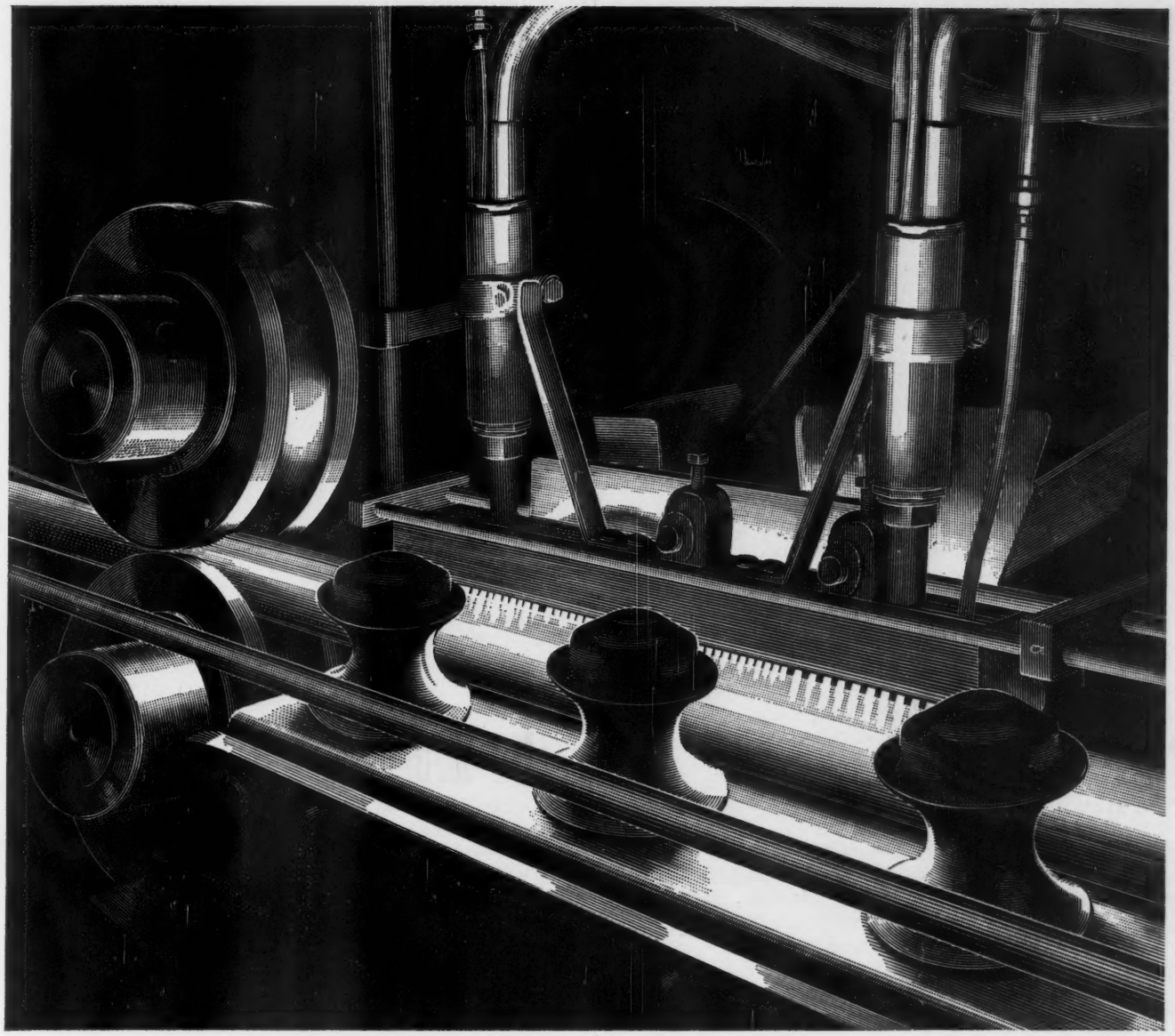
Upon his return to the United States, Coolidge at once began his brilliant career of research with five years of physico-chemical investigation into the conduction properties of aqueous solutions at high temperatures, under Dr. Arthur A. Noyes at M.I.T. At the Institute his laboratory adjoined that of a certain Dr. William R. Whitney, and when the latter was made Chief of Research at General Electric's Schenectady laboratories, he sent out an urgent appeal to Dr. Coolidge to join him. Reluctantly the latter consented to leave M.I.T. for General Electric, with the idea in mind that he was to bring his equipment with him and continue the work he had started. But, once in Schenectady, the current research problem of developing a new type of lamp filament so absorbed and fascinated him that, when in 1908 he was made Assistant Director of Research, he completely dropped his conduction experiments and set out to solve the filament problem.

Although the incandescent lamp had come a long way since Edison perfected the first carbon filament, there was still much to be hoped for, and metallic filaments, at first made from an osmium-iridium alloy, were still in the early stages of development. The first tungsten filament had been introduced from Europe, but this was a very fragile loop. The problem was to make a more durable tungsten filament. Dr. Coolidge began by developing an improved, but still not perfect, process, substituting an amalgam for the European binder used to hold together the tungsten particles. In the fall of 1908, after having tried method after method, he finally produced, by working the metal at high temperatures, what no man had ever seen before, ductile tungsten. The next difficulty was in developing the industrial application of the process. After two years of lengthy investigation, he was able, commercially, to draw tungsten into wire by a process known as hot-swaging. This discovery not only revolutionized the incandescent lamp industry, it also paved the way for further developments like the discovery of gas-filled bulbs, by Dr. Irving Langmuir, Coolidge's laboratory associate.

Having developed a method for making tungsten ductile, Coolidge turned his efforts to further applications of the metal. After the discovery of its superiority to all other metals in ignition contacts, he turned to the field of X-ray, for which research he is best known to the general public. The first X-ray tube was a hit-or-miss affair. The power it used and the intensity of its rays depended upon the amount of gas in the tube. To control the tube, a side-tube had to be provided for generating gas. When it was shown that electron discharge was possible from a high vacuum tube, Coolidge hit upon a radically new idea. By evacuating the tube to the best vacuum possible, he found that it was possible to control the X-ray intensity by controlling the anode (plate) temperature. This new type of tube proved so successful that it rapidly superseded all others. With the Coolidge tube the use of X-rays became a science instead of an art.

About this time, the United States entered the first World War. One of its first problems was combating the submarine menace. Dr. Coolidge set out at once to develop and perfect the crude submarine detector then in general use, and, by finding that the rubber tube was a more effective detector than the diaphragm to which it was attached, he perfected the "C" and "K" submarine detector tubes, reducing the submarine menace to almost nothing.

He entered General Electric in 1903, became Assistant Director of the laboratory in 1908, Associate Director in 1928, Director in 1932, and Vice-President and Director of Research in 1940. He retired from active research in 1932, but his influence and wise judgment is felt and appreciated in all of the laboratory's work. Coolidge is a tireless worker with an objective scientific mind and a knack for getting quickly to the base of any problem with questions and observations. That Dr. Coolidge's discoveries and inventions (he is a holder of 83 patents) have wrought many profound changes in our life is undeniable. He is also the holder of many medals and honorary degrees, he is a member of many scientific organizations and societies, and was a member of the M.I.T. Corporation from 1930 to 1935.



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Tubing produced by this Airco automatic welding method is characterized by strength, shock-resistance, and uniform wall thickness—and especially by its speedy manufacture and low cost.

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This use of the oxyacetylene flame is another example of how Airco research is extending the benefits of flame and arc processes to many manufacturing operations. By constantly increasing the efficient application of these processes, Airco research has broadened their usefulness to industry.

If you want to keep posted on flame and arc developments, write for a free copy of "Airco in the News." Address Air Reduction, Room 1656, 60 East 42nd Street, New York.

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QUALITY CONTROL

(*Continued from page 7*)

long runs like that shown on this chart that reduce unit costs, increase production, and produce good quality parts which require no inspection later.

Table IV shows the history of the production of four successive days, three days when the control chart was used and one day when the control chart was not used. It might be argued that the period covered is not long enough to provide us with conclusive evidence. These are short runs; some orders are even shorter. But the pattern of the history is always the same, proving conclusively the value of the control chart for controlling quality.

Statistical methods require that the person using them have some training in these methods; they also require an understanding and sympathetic attitude on the part of the production organization, "the shop people." It is a fact that the initial inspection and calculations to determine the average, $(\overline{X})$, and the standard deviation, (σ), require an appreciable time and sometimes it is difficult to explain to "the shop people" that this work is necessary. To overcome these objections, a system of "first-piece+patrol+last-piece" inspection has been developed which can control quality so that the production of defective parts is practically eliminated. This method is particularly adaptable to punch press operations, welding and brazing operations, grinding operations, and fixture assembly operations where several parts are assembled and riveted in a machine. This method also has been used on automatic and semi-automatic screw machines, turret lathes, and when grinding journals on shafts. This method requires no training beyond that possessed by the inspector who is to inspect the work.

After a set-up has been made and properly adjusted, it is allowed to run fifteen or twenty minutes to allow the tools to become seasoned. This allows the edges of cutting tools to become stabilized and holding and locating fixtures to become set. After this initial seasoning period two or three pieces are taken by the operator and carried to a "first-piece inspection station." Here the inspector gives these pieces a thorough inspection; all dimensions are carefully checked; the height of burrs, when present, is observed; the hardness of the

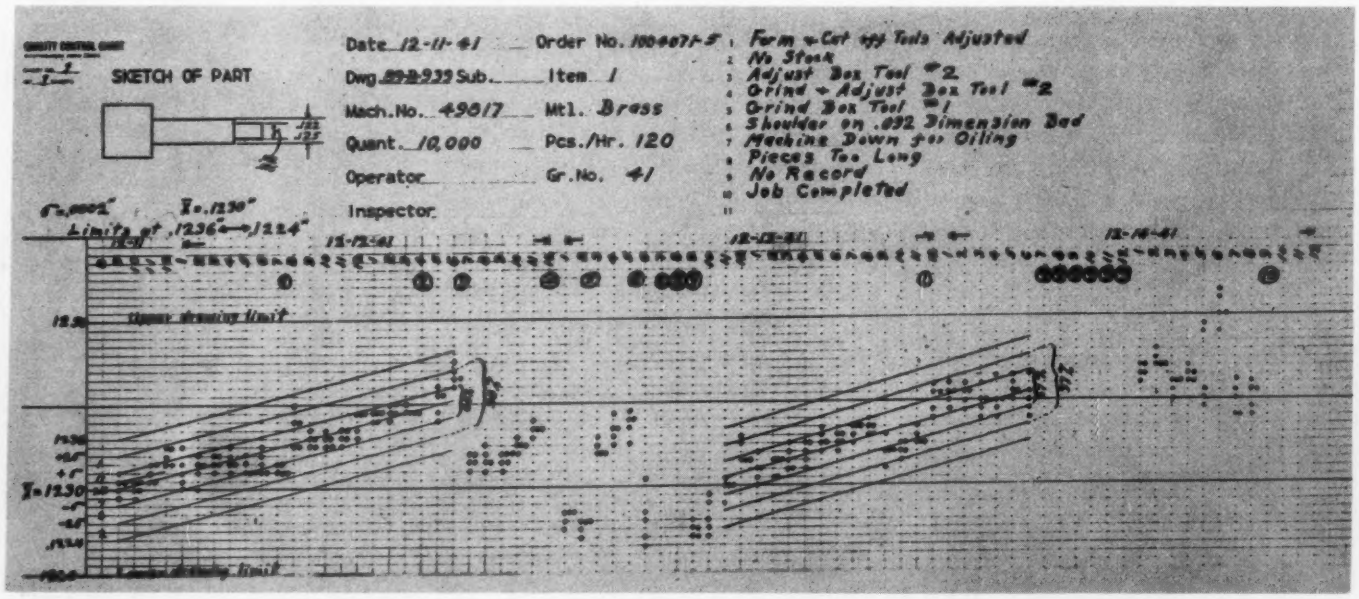
Fig. 5. First-piece inspection station serving punch presses, welding and brazing machines and assembly operations

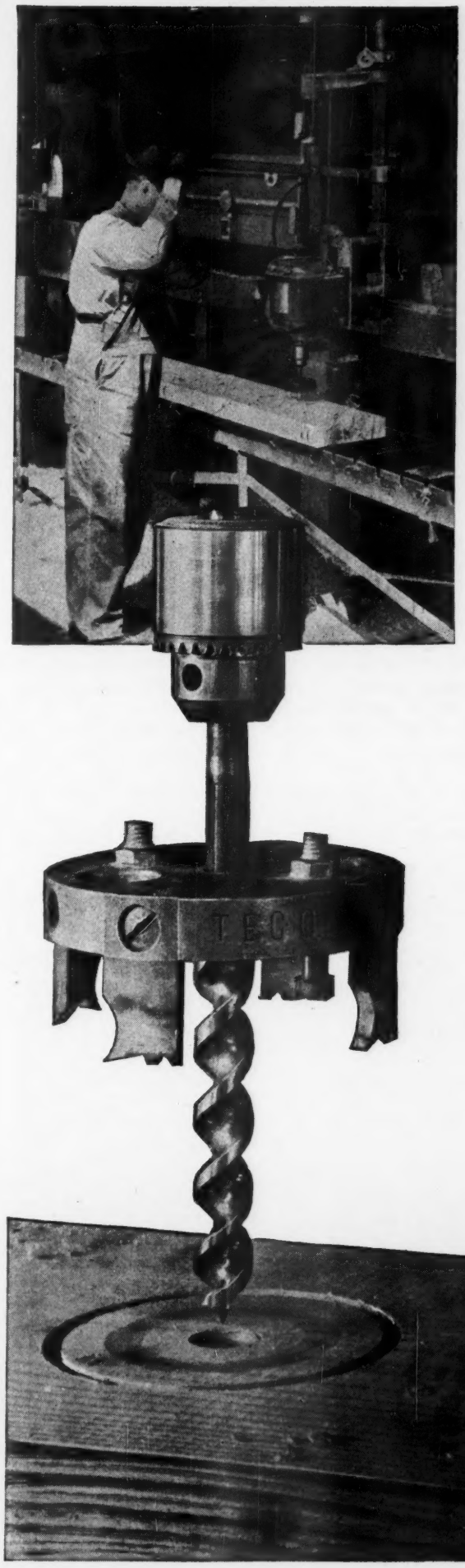
material is measured; and the shape of threads is observed. This inspection station is equipped to perform any inspection required on the parts coming through. The inspection station shown in Figure 5 is supplied with a Rockwell hardness tester, spring testing machine, strength-of-weld testing machine, surface gages, height gages, magnifying glasses and vernier calipers. Special functional fixture gages are provided for intricate parts; gage blocks and electric gages are available when needed.

If the part or parts pass this initial inspection and are approved by the inspector, he makes out "Operation Inspection Tag, Form 21166-B" shown in Figure 6. The inspector shows on this tag the complete identification of the part by part number, the shop order on which the part is being made, and a description of the operation or operations which result in the production of the part. The identification of the material by material number is also shown by the inspector and he must

(*Continued on page 24*)

Fig. 4. Typical control chart showing the long machine runs made possible when cutting tools are properly dressed and set-ups properly made





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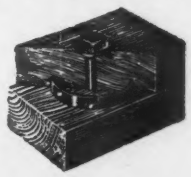

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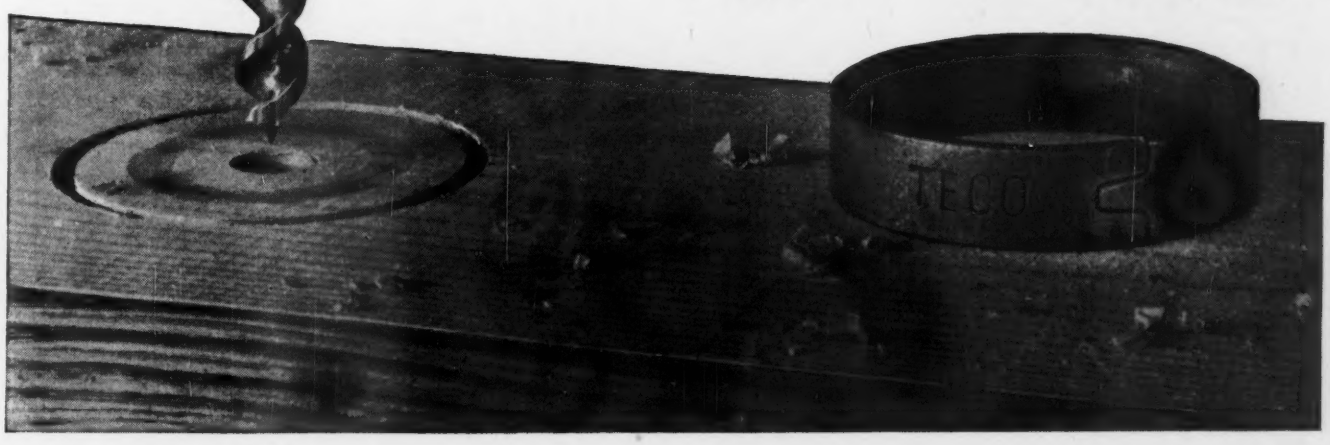


QUALITY CONTROL

(*Continued from page 22*)

satisfy himself that the part is made of that material. The date and time of day when the part is approved are shown on the tag as is also the signature of the inspector and the designation of the manufacturing section.

Figure 6 shows an operation inspection tag completely made out. This tag, together with the part, is returned to the operator as his authority to proceed with the operation. Ordinarily the operation is shut down until the first piece is approved, but under exceptional circumstances the operator may proceed with production. In this case if the first piece is not approved, all parts produced must be inspected 100 per cent until a satisfactory set-up is made.

The operation inspection tag and the first piece which was approved by the inspector must both be displayed prominently at the work station while the operation is in work. Figure 7 shows a battery of spot welders and the manner of displaying the operation inspection tag. The inspector has authority to shut down any operation on which the operation inspection tag is not shown.

This first-piece inspection is followed by periodic patrol inspection of the operation. This patrol inspection may be made every hour in the case of automatic screw machines; every two hours in the case of spot welders and brazing machines; every three or four hours in the case of punch presses or molding operations. The length of time between inspections is determined by rapidity of tool wear, the closeness of the tolerances to which the parts are made, and the degree to which the operator has been made "quality conscious."

When making this periodic patrol inspection, the inspector walks up to the machine performing the operation and observes conditions in general. Is the die properly lubricated? Is the material being fed through the die clean and of the proper dimensions? Is it fed through

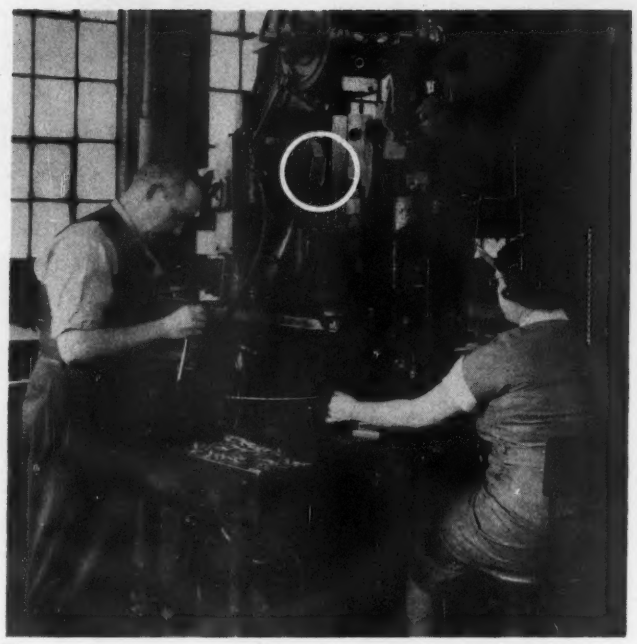


Fig. 8. An inspector making his rounds on patrol inspection. Note the operation inspection tag on the side of the punch press, directly above the push button.

properly? Is the work area clean and orderly? Is the operator observing safety rules? On a welder, is the timer functioning properly? Is the transformer too hot? Are welding tips worn or mushroomed? Is cooling water of the proper temperature? He then watches a part being made and inspects *that* by comparing it with the part approved at "first-piece inspection." The two parts should be identical; any difference between them must be accounted for, as tool wear, shift in locating pins, or other changes in the set-up.

If the part is satisfactory, the inspector enters the

(*Continued on page 26*)

Fig. 6. Operation Inspection Tag, Form No. 21166–C. This serves as a complete log of the running of the job.

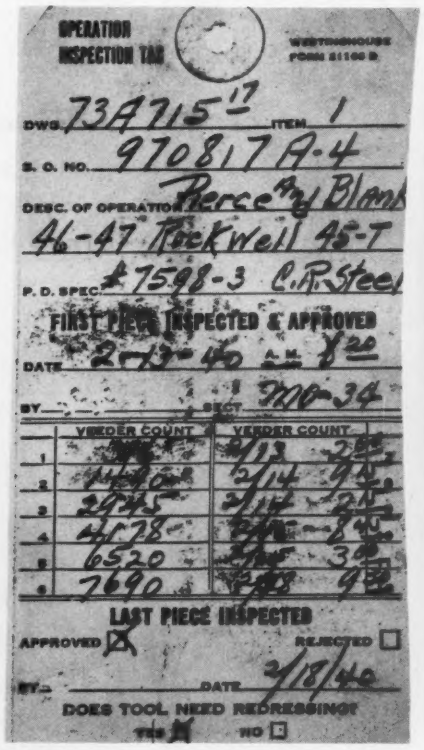


Fig. 7. A battery of brazing machines. Note the tag and the approved "first piece" directly in front of each operator

To the Young Man Who is . . . . . Or who is about to . . .

What we folks at home are trying to do about postwar may seem sometimes remote and obscure. You haven't had much chance to get acquainted with peacetime industry, and to see it in its true role as a creative job-maker.

Take our own business, Alcoa Aluminum.

You know about the tremendous expansion in aluminum capacity. You see most of this seven-fold production going into the planes you are going to fly, the planes that will be your cover on the attack.

But Aluminum's true role is no more military than yours is. Both of us do have an immediate job to do; and then, the future—

Ever stop to think how many things in this old world are crying to be made lighter? Or how many ingenious, imaginative young men are going to be needed to apply and sell and manufacture the more than two billion pounds of aluminum that will be available every year when this thing is over?

Actually, we see the possibility of a million jobs, doing something with aluminum in peacetime, a million new jobs that did not exist before this war. There are grand careers ahead in aluminum!

We are devoting our eighth day of thinking time to doing what we can to make those careers as certain as anything can be. We call it Imagineering: letting the imagination search the realm of new products and new applications, and then engineering the dreams, the hunches, the markets, into clear paths to follow, someday.

Perhaps one of those paths will be yours to follow in the future.

A PARENTHETICAL ASIDE: FROM THE AUTOBIOGRAPHY OF

ALCOA ALUMINUM

• This message is printed by Aluminum Company of America to help people to understand *what we do* and *what sort of men* make aluminum grow in usefulness.

QUALITY CONTROL

(*Continued from page 24*)

time of this inspection on the operation inspection tag. He also enters the total number of pieces which have been made up to the time of this inspection, if this information is available from a counter. If the part is not satisfactory, he removes the operation inspection tag from the machine and this automatically shuts down the operation. The operator then proceeds to correct the tools, or set-up, so as to bring the operation in control once more, or if he cannot do this by himself, he reports to his foreman.

All parts produced up to the time of the patrol inspection should be physically removed from the work area. If this cannot be done, these parts should be separated from parts produced subsequent to the inspection. The purpose of this separation is to avoid mixing good parts with defective parts in case something should happen to the set-up which would result in the production of defective parts.

At the end of the production run, the last one or two parts produced are inspected very carefully. The purpose of this inspection is to detect any changes in dimensions or quality between the first part inspected and this, the last part. These changes are interpreted in terms of tool wear, and the inspector decides whether the tool should be dressed, ground, or adjusted in any way before another order is started. He denotes this condition of the tool by checking the proper square, YES, or NO under the question "Does Tool Need Redressing" at the bottom of the operation inspection tag, Figure 6.

If the tool needs redressing, the inspector makes out a D-A Salvage Tag, shown in Figure 9. The foreman, as well as the inspector, signs this tag. The act of signing this tag serves formal notice on the foreman that he has a tool in his department which requires regrinding.

All completed operation inspection tags are filed by part number. All tags pertaining to any part may be taken from this file and reviewed at any time. From this review it can be determined whether the part is one which is difficult to make to required quality standards, in which case a change in design, tooling or method of manufacture might be advisable. If this review reveals that set-ups, once made, continue to the end of the order, and no defective parts are produced, then it can be assumed that the method of manufacture is satisfactory from the point of view of quality control.

TABLE III

Variation of the Percentage of Defective Parts Produced Day by Day

History of Part Before Application of Statistical Control

Date	Number Inspected	Number Rejected	Per Cent Defective
7–18	1,240	97	7.8
7–18	1,240	381	30.7
7–20	1,144	194	17.0
7–28	1,478	198	13.4
7–28	1,130	370	32.3
7–28	1,549	919	59.3
7–31	1,457	257	17.6
7–31	2,090	450	21.5
7–31	1,193	83	6.9
8–2	2,200	630	28.6
8–2	1,850	322	17.4
8–3	2,150	300	14.0
8–3	1,860	392	21.1
8–4	1,327	287	21.6
Total	21,908	4,880	22.3

TABLE IV

Results Obtained With and Without the Use of the Control Chart

History of Part After Control Chart Was Established

Date	Number Inspected	Number Rejected	Per Cent Rejected	Control Chart Used
5–2	1,120	2	0.2	Yes
5–3	950	3	0.3	Yes
5–4	840	17	2.0	Yes
5–5	850	117	12.0	No

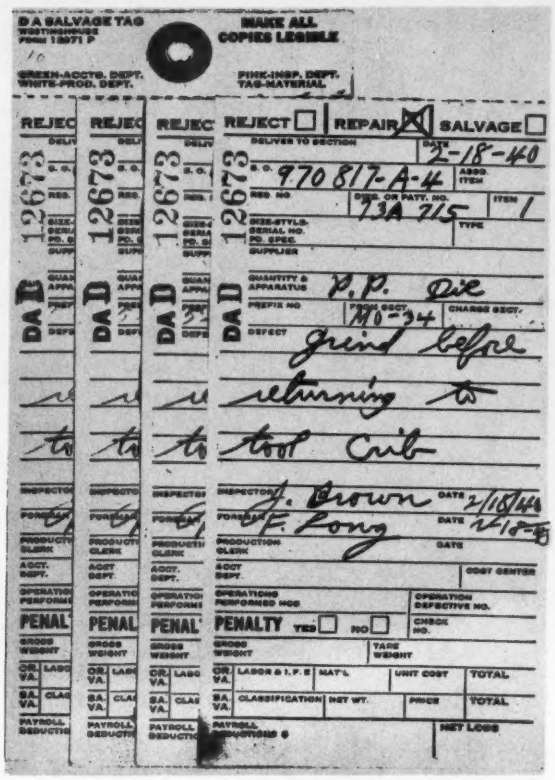
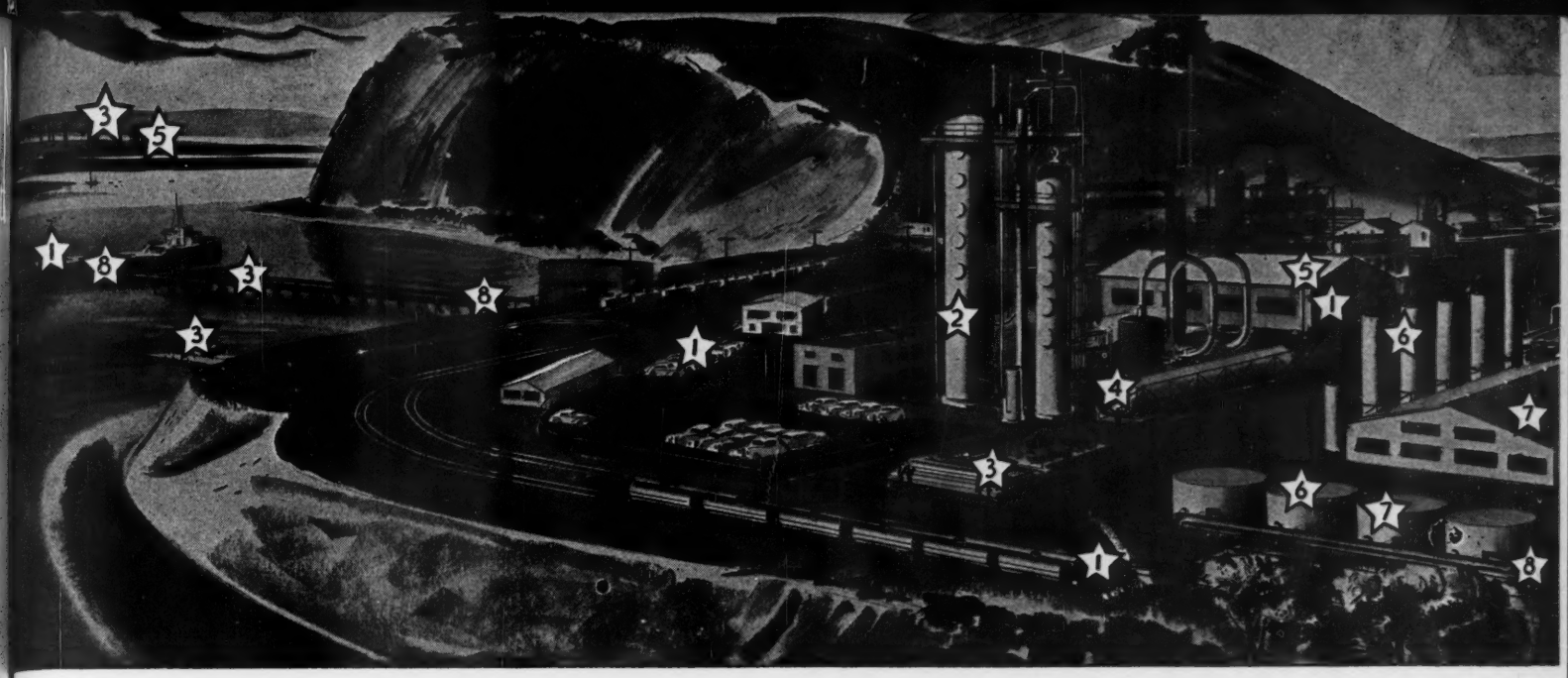


Fig. 9. A D-A Salvage Tag is made out for all parts or tools which do not meet the required standards or specifications

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

BUY WAR BONDS



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A recent book on chemicals says that American motorists, when they *were* allowed to use their cars, burned enough gasoline each year to fill Great Salt Lake twice over. Great Salt Lake is 80 miles long, 20 to 30 miles wide and averages 18 feet deep.

Since oil yields only about 25% of gasoline in straight run distillation, this would have meant fantastic over-production of the lighter and heavier "cuts."

To meet this situation, the oil industry "manufactures" gasoline by building up the lighter hydrocarbons and breaking down the heavier ones. Normally, more than half the gasoline we burn is "manufactured," most of it from oil fractions that originally contained no gasoline at all.

To do this, the oil business has become one of the greatest chemical industries in America.

Koppers, too, is a great chemical business. Working with coal derivatives, it is currently helping the oil industry make more 100-octane gasoline by furnishing coal tar benzene for a chemical process which improves the octane rating of low-octane gasoline.

Koppers is also furnishing to the oil industry: plants for purifying gas . . . piston rings . . . self-aligning couplings . . . pressure-treated timber and other products. Koppers Company and Affiliates, Pittsburgh, Pa

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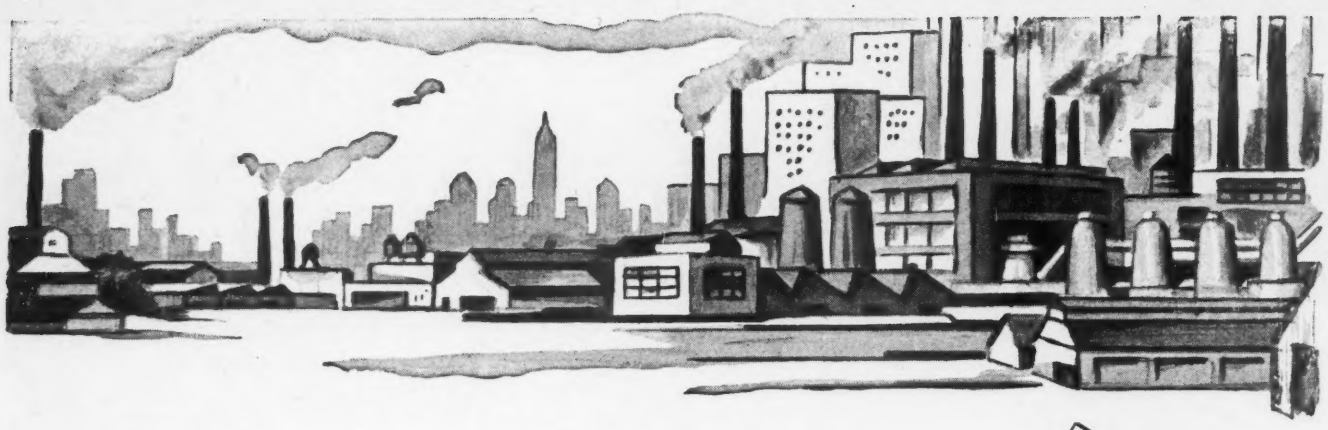

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X-RAY METALLOGRAPHY

(*Continued from page 18*)

Gas hole: a small, round defect of gaseous origin which is surrounded by metal.

Air pocket: a larger and more isolated pocket, also of gaseous origin, not necessarily round.

Inclusion: any extraneous matter which has become enclosed in the metal.

Crack: any crack or fissure.

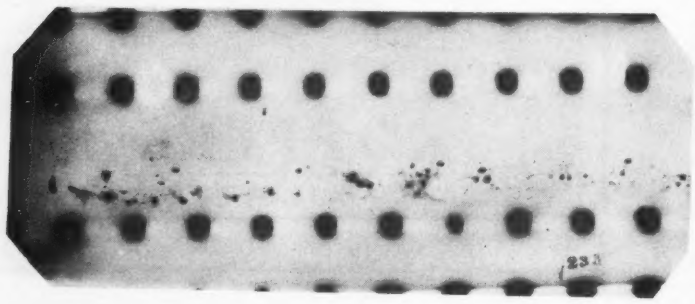
Porosity: a condition, rather than a diagnosis, caused by groups of holes, etc.

Cavity: any unfilled local area.

Cold shut and fold: two streams of metal which hardened before complete coalescence.

Shrinkage: folds of metal which have shrunk and separated.

Electric-arc weld on steelplate. The round holes were drilled in the plates. The line of the weld is just above the bottom line of holes. The spots are blow holes and gas holes.



Segregation: Separation of the components of the metal.

The largest use of X-ray metallography has been in connection with welds. In this field the X-rays have two uses: routine examination to assess the soundness of the weld, and research and instruction in welding technique.

Defects likely to be found in welds can be divided into two classes — microscopic and macroscopic defects.

The microscopic faults are defects or damages to the microstructure of the parent metal or weld metal, such as decarburization of higher-carbon steels or stresses which have not caused cavities.

The second class, much larger than the first, includes imperfect fusion between the parent and weld metal, improper filling, slag inclusions, oxidation at the edge and most of the other catalogued defects.

Figure 1 shows the methods of approach for taking radiographs of different types of welds. Diagrams (*a*), (*b*), and (*c*) show the proper approach for the butt weld. In the lap weld, (*d*), a radiograph taken at *A* will be satisfactory for this part, but the union at *B* will not be shown in such degree as to be examined. Thus it would be better to take the radiograph at the angle *C*, and make allowances for distortion. Diagram (*e*) shows the offset method as applied to welded-tube inspections. Diagram (*f*) shows a method which offers a view through the surfaces of the weld; this will disclose separations undetectable by other methods. Diagram (*g*) shows a similar method suitable for fillet welds in *I*- or *T*-sections.

The newest use of X-rays, the measurement of stresses, is still in the experimental stage. This mensuration is possible because all changes in the physical

(*Continued on page 30*)

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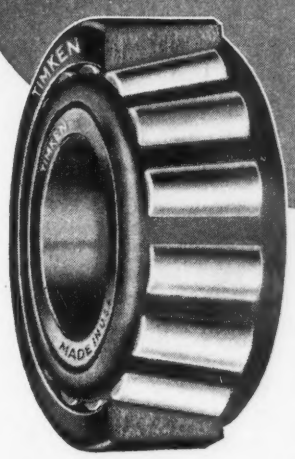

THE new world —the world of the post-war era — will be a world of wheels to a greater extent than ever before. The development of new kinds of production and transportation equipment, and the recreation of existing machines will greatly increase the necessity for and importance of bearings capable of meeting new conditions of speed, precision, load capacity and endurance.

Then the same bearings that have consistently and successfully anticipated so many revolutionary developments for more than three decades, again will rise to the occasion with the same versatility and efficiency — Timken Tapered Roller Bearings.

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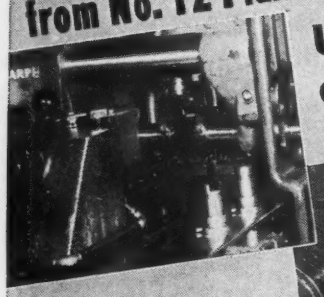

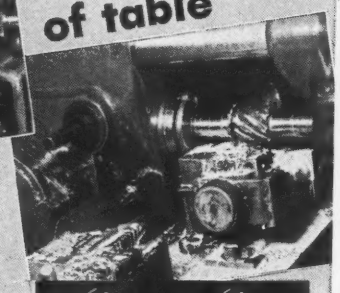

Climb mill in one fixture and conventional mill in the other—one machine and one set of cutters often can do the work of two.

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X-RAY METALLOGRAPHY

(*Continued from page 28*)

condition of metals cause corresponding changes in the atomic structure. Thus if the elastic strain varies from grain to grain, the angle of diffraction will also vary, giving a widened diffraction line on the photographic plate. If all the reflecting grains are stressed similarly, the diffracted rays from all of them will produce sharp lines displaced from the normal unstressed positions. This method, then, is really using X-rays as a sensitive extensometer with inter-atomic distances as a gage length. By combining the elastic strains, calculated with this extensometer, with the elastic constants, the surface stresses can be calculated. Even though the inter-atomic distance is only about a hundred millionth of an inch, a change of one part in 10,000 can be observed.

If the specimen is set up as in figure 5, the diffracted cone of rays will be recorded on the film as a circle. If the distance between the specimen and the film is known, this circle serves as a measure of the inter-atomic distance. If one photograph is made unstressed and another stressed, the difference in radii of the concentric circles will give the elastic strain.

Since the film-to-specimen distance cannot be accurately measured for every specimen, another method has been devised for calibrating the film. A thin layer of metal powder, usually gold or silver, is applied to the surface of the specimen, giving a diffraction cone of known apex angle. Thus, this circle is recorded on the film along with that of the specimen and the film is automatically calibrated.

The uses of X-ray metallography in industry have become more extensive since the outbreak of the war. It supplied the metal industry with an inspection technique —sure, quick and non-destructive. Welding on a large scale has been made possible because the weld could be tested before it failed, by the use of X-ray metallography. The years of experimenting with X-rays have proved their worth.

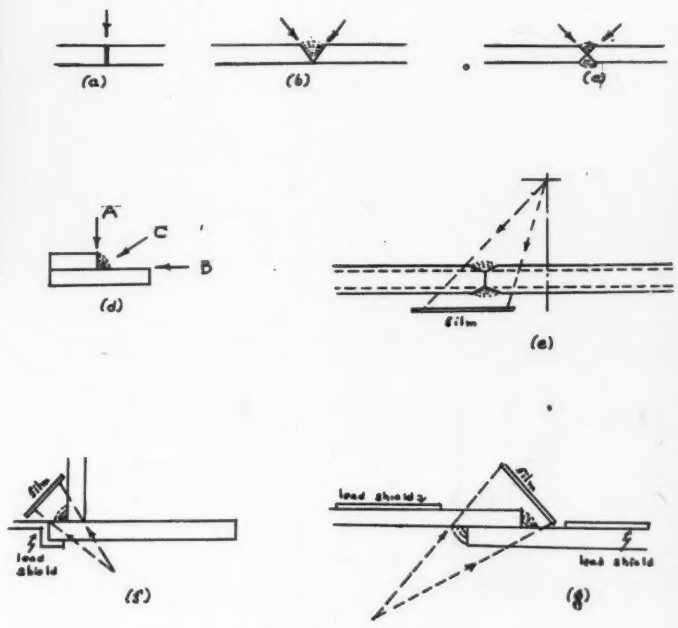
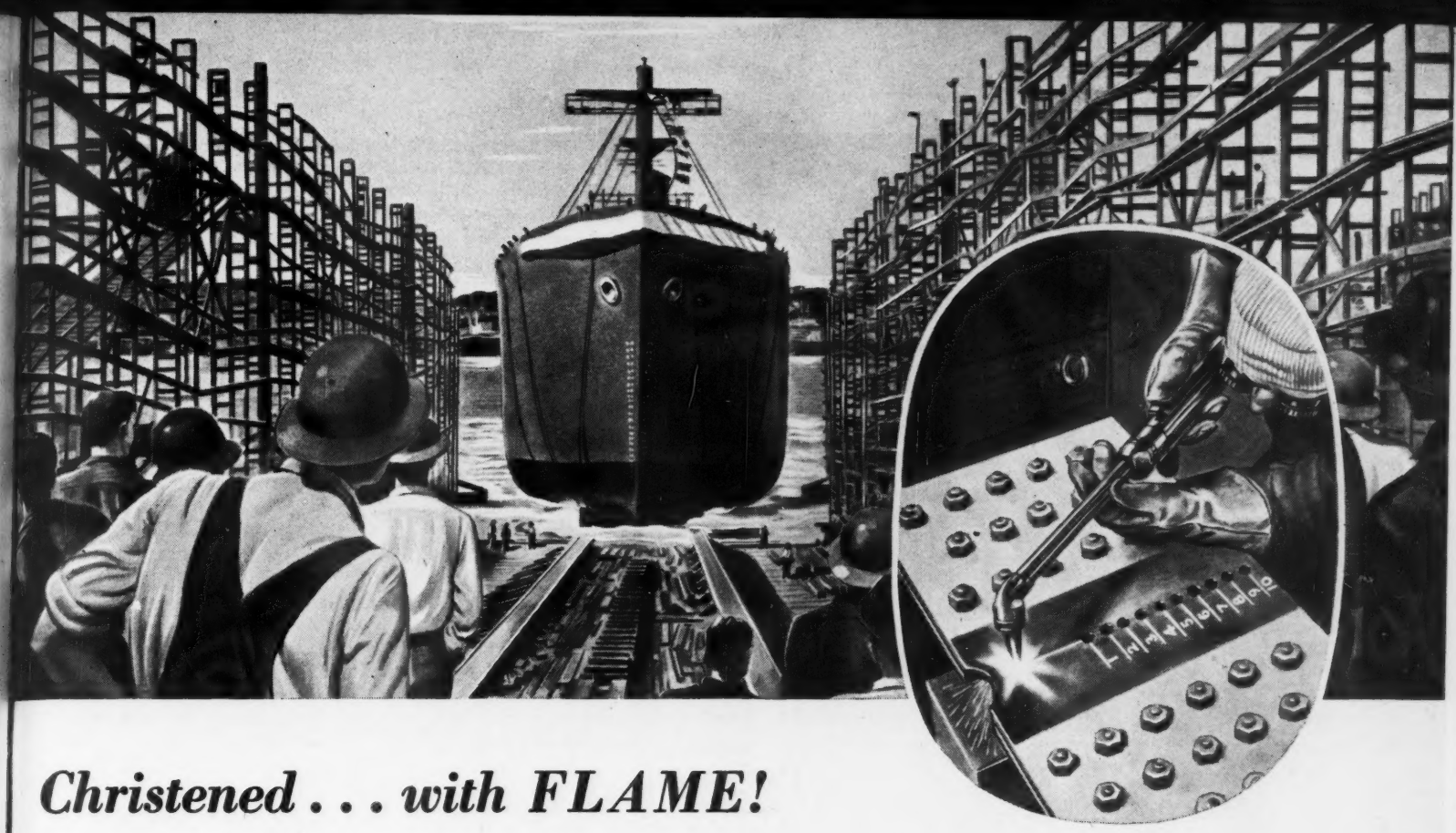


Figure 1

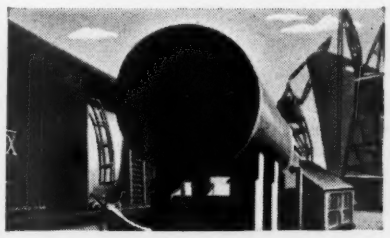


Christened . . . with FLAME!

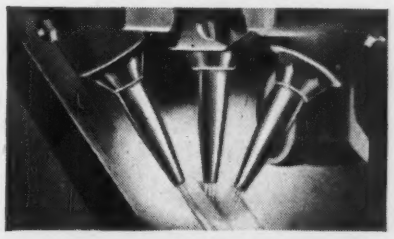
FLAME . . . as well as champagne christens ships. The last act that frees a ship from the ways is the cutting of steel bonds by oxy-acetylene flame. This swift cutting of steel typifies the way the oxy-acetylene flame is speeding the fabrication of ships, aircraft, locomotives, guns, shells, tanks, and hundreds of other vital articles made of metal.

All over America, this flame cuts time and gives to mass-production industries a means of manufacturing faster, better, and at lower cost. Since the white-hot oxy-acetylene flame cuts through metal as easily as a saw through wood, it makes steelworking as simple as carpentry! From the time steel is made . . . until it is finally cut up for scrap and sent back to the steel mills for a new lease on life . . . oxy-acetylene flames expedite its treating, cutting, and fabricating.

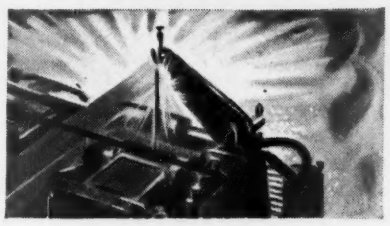
The oxy-acetylene flame is not new. Oxygen, acetylene, and many machines and techniques for treating, cutting, and fabricating metals have been made available to industry for years by THE LINDE AIR PRODUCTS COMPANY, a Unit of UCC. The present wide application of Linde's peacetime research and development . . . coupled with the great expansion of Linde's oxygen-producing and engineering facilities *before* the emergency arose . . . are contributing vitally to this country's mass output of the things it needs. These products and processes—plus new ones that are stemming from today's continuing research — are important among the mass-production tools that can be used in the future to bring you better cars, trucks, tractors, washing machines, refrigerators, and many other things for better living at lower cost.



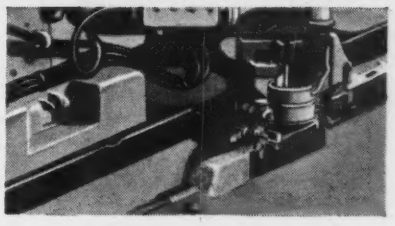
LIQUID OXYGEN! The demand for oxygen today is great. Driox liquid oxygen has made it possible for mass-production industries to be supplied in bulk. Liquid oxygen—occupying only 1/862 of the volume of gaseous oxygen—is shipped in tank cars and tank trucks and converted to gaseous oxygen as needed.



KNIVES THAT NEVER DULL! Oxy-acetylene flames held in mechanical arms trim and bevel steel plates for welding in a fraction of the time required by methods formerly used . . . cut in straight lines, circles, or in irregular patterns. The flames are also used to harden and soften metals and to prime them for painting.



SPEEDING QUALITY STEELS! Production line efficiency in removing surface blemishes from new steel became possible with the Lin-de-Surfacer scarfing machine. Huge mechanized batteries of oxy-acetylene flames "skin" hot steel . . . quickly and economically . . . resulting in higher yields of quality steel.



MECHANIZED WELDING! "Unionmelt" electric welding automatically joins steel plates as much as 20 times faster than any similarly applicable method . . . and does it without noise, fuss, or sparks. This process complements the hand and mechanized methods of welding with the oxy-acetylene flame.

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PLASTICS
Bakelite Corporation
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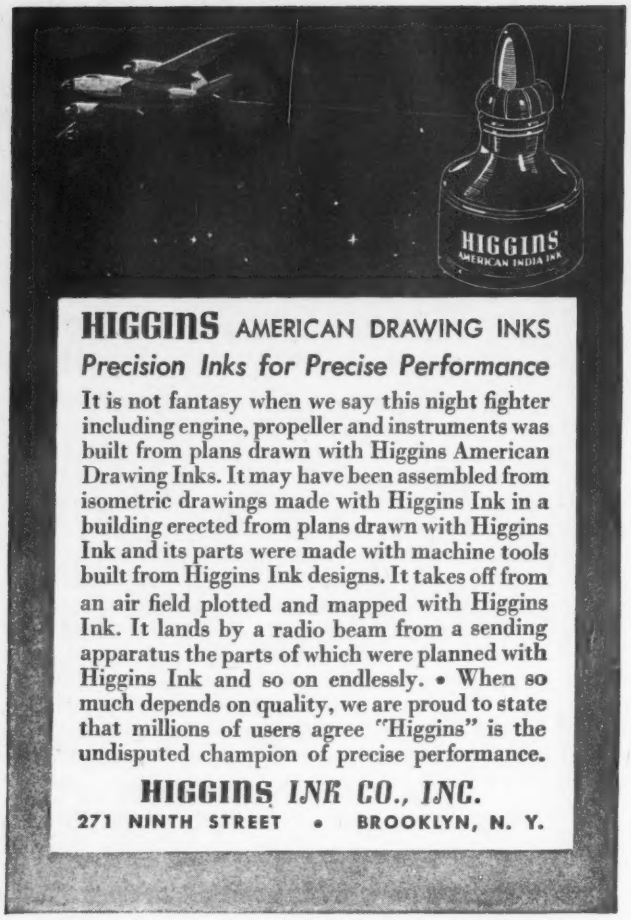
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PEACETIME SALVAGE

(*Continued from page 9*)

greatly reduces the cost of the photographic film required, and with but little sacrifice, we are told, in diagnostic value. This makes economically possible the chest radiography of all army recruits and the frequent chest examinations which are so desirable in the case of our young people.

Leaving the X-ray field, it may be of interest to note that the precision metal-casting method on which we rely for the making of dentures is playing a very important role in the war, making it possible to cast accurately to size alloys which cannot be forged or machined but which possess in one or more respects better physical properties than those alloys which can be handled in the ordinary way. This is only one of the many important metallurgical advances which are being made.

During the war the electron microscope has undergone intensive development and is a tool which enormously broadens our horizon by taking us way beyond the limits of the optical microscope — down, in fact, to the size of the largest single (virus) molecules.

Radio

In radio, tremendous advances are taking place which are not only vital in the war effort but will be of inestimable peacetime value, permitting us to see distant objects in the dark and through a fog and so enabling us to avoid collisions at sea and to enter harbors under poor conditions of visibility, to avoid collisions in the air and to make safe blind landings.

Much of our wartime work in radio will contribute to making television in peacetime a widespread educational and entertainment feature in the home. I do not think that we realize at all what that will mean to us. It should even result in better government. It will give us much stronger feelings about the candidates for whom we vote. We get a great deal from the content of a speech and from the sound of a voice, but it will be helpful for us to *see* the speaker.

Chemistry

In chemistry we see great advances being made, especially in the organic field in the production of long-chain polymers. These constitute the basis of the plastics industry and include paints and varnishes, molded compounds, synthetic fibers and the various synthetic rubbers. The mechanical and electrical properties are determined by the composition, size and configuration of the molecule, and the chemist has already made wonderful strides in learning how to control these — he is tailoring the molecule to fit the specific purpose for which it is to be used.

In these days of rationed gasoline, we are all aware of what the automobile has done for us in the past in broadening our horizons. It may have tended to atrophy our legs, but for those of us living in cities, as most of us do, it has been a great boon. For one thing it has given us a contact with nature that we should otherwise never have had.

Aviation

After the war, aviation will take us as far from automobile days as the automobile took us from the horse-and-buggy age. It is hard to realize today the extent to which this is true — the speed, the increase in safety, the ability to travel in all weathers, the possibilities of the new helicopter in taking us from our own dooryard to our camps or to commercial airplane fields.

Thanks to this war, this generation is certainly learning geography at a rapid pace.

Substitutions — New Developments

While we are throwing away critical materials at an enormously greater rate than ever before in the world's history, we are at the same time learning the value of these materials and how we can make them go farther by the use of substitutes. Furthermore, many of the substitutes will be better for the purpose in question than the original materials.

We will profit not only from the developments of the new principles, new materials, new devices and new methods, but also in other and no less important ways. I refer to the sociological gains which we are unconsciously making. The war is doing away with isolationism, not only in an international sense, but also in a narrower sense right here at home. People in the most varied walks of life are being brought into close contact with one another. This is true not only in the armed forces but also in our civilian population. Generally speaking, we, like the English, but to a lesser extent, have preserved a considerable aloofness from others. Among scientists there has been quite a gap between those of the so-called pure and those of the applied science variety. War work has already, I think, effectively bridged this gap.

This summary of wartime research presents but a general cross-section of the rôle science is playing in the war. As with many of the benefits of our wartime research program, we will have to wait until after peace is declared to learn the details of the work and to appreciate its nature. But, when these details become known, everyone will profit, for most of the discoveries made by our scientists can be directly applied to the happiness and well-being of a war-tired world. There is ahead of us a giant task, that of peacetime salvage from our wartime research.

Here's one Nazi broadcast that's the Gospel Truth!

U.S. TANK IS BEST, SAY NAZI EXPERTS

Germany Will Doubtless Copy Gyroscopic Feature of General Sherman Tank, Berlin Radio Declares

By The Associated Press

A special new German institute for testing captured tanks has adjudged the American "General Sherman" the best type the Allies have turned out, the Berlin radio said yesterday, adding that the Nazis "doubtless" would copy its construction—particularly the gyroscopic gun-mount, which they consider its outstanding feature.

"Doubtless" Best Type

"According to the findings of the Institute," said the broadcast, recorded by the Associated Press, "the 'General Sherman' tank is doubtless the best type the allied armament industry has yet produced.

"A special innovation on this type tank, which by a gyroscopic system prevents the gun from being affected by the jolting of the tank when traveling on rough grounds, greatly interested the German experts. They believe this to be the first attempt at borrowing from the construction of warships for the construction of arms for warfare on land, and doubtless it will be copied soon."

WHEN THE GERMAN RADIO paid glowing tribute to the General Sherman tank—for once it was telling the truth.

You see, tank battles used to be stop-and-go affairs, because a tank's heavy cannon could be aimed accurately *only when the tank was at a complete standstill.*

That was bad—because every stop naturally made the tank a juicy target for the enemy.

Then the Army Ordnance Department called on American industry for the solution of this problem. So the men of Westinghouse went into a huddle. And out of it came what has been called one of the greatest military developments of this War—a tank gun stabilizer that permits *incredibly accurate fire while the tank is charging ahead at full speed over rough ground!*

And then, to button up the job, Westinghouse went into production on these gun stabilizers so fast and so thoroughly that almost before you could say "El Alamein," they were being produced in sufficient quantity to equip every American tank!

No wonder the Germans thought well of the General Sherman. And no wonder they considered its gun stabilizer its outstanding feature. For this one device has revolutionized the whole combat technique of tank fighting!

For us, tank battles are no longer stop-and-go affairs, with every stop offering the enemy a "sitting pigeon." American tanks are now more than 500% deadlier than ever before.

And the Westinghouse Research Laboratories, which developed the device—the Westinghouse engineers, who perfected it—and the men and women of Westinghouse who make it in great numbers—are proud as Punch.

Westinghouse Electric & Manufacturing Company, Pittsburgh, Penn.

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DEC 17 1943

GE Campus News

RESEARCH AND ENGINEERING KEEP GENERAL ELECTRIC YEARS AHEAD

THE "BAZOOKA"

SERENADES by the Army's "bazooka" corps are getting hands in the air on the enemy front and handclapping from the folks back home.

This new anti-tank weapon, dubbed the bazooka from some remote resemblance to Bob Burns' blow-pipe, is small enough to be fired by one man, after a second man loads it. It hurls such a powerful projectile that, after one shot struck a nearby tree, the commander of six enemy tanks surrendered them, believing that he was being shelled by 155-mm. guns.

"It is so simple and yet so powerful," said Major General L. H. Campbell, Jr., Chief of Army Ordnance, "that any foot soldier using it can stand his ground with the certain knowledge that he is the master of any tank which may attack him."

For over a year the bazooka has been in mass production at a General Electric plant that formerly made washing machines and other home appliances.

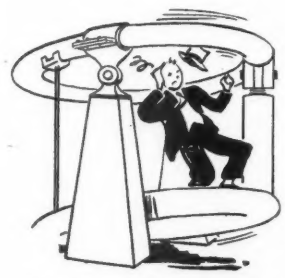
THE LIFE OF ITS LIGHT . . .

. . . is only *one* second, yet so short is each flash that it can be used to take 1,000,000 individual photographs! "It" is the 1000-watt MAZDA mercury lamp in General Electric's new "speed-light" camera.

The device consists of a small box weighing less than 25 pounds. The light source is on the front, like a small head light and can be operated manually with a push-button or automatically by electrical contacts or photo-tube and preamplifier. An ordinary 115-volt a-c household lighting circuit is used to operate the unit.

The lamp itself is about the size and shape of a cigarette and will illuminate 20 square feet of area brightly enough to photo the fastest moving objects. In tests photographs have been taken of a wheel revolving at 70,000 revolutions per minute.

Use of the unit so far has been confined to studying high speed machinery, such as turbines and supercharger parts.



MAL DE MARS

TIME was when the testing of marine equipment had to be done at sea, aboard the type of ship for which the equipment was intended. Now, however, with machines such as the Scorsby tester in G.E.'s Aeronautics and Marine Laboratory the range of detectors and other equipment can be checked right on land, against a fixed horizon.

The device simulates the roll and pitch of a moving ship—and the resulting seasickness. The time of the ship's complete roll can be duplicated—all the way from the nine seconds for a destroyer to the eighteen seconds for aircraft carriers.

The tester is capable of holding 10,000 pounds and is composed of two huge iron doughnuts, the lower one platformed, which are held about four feet apart by two motor-driven arms. *General Electric Co., Schenectady, N.Y.*

Hear the General Electric radio programs: "The Hour of Charm" Sunday 10 p.m. EWT, NBC—"The World Today" news, every weekday 6:45 p.m. EWT, CBS.

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